



UNIVERSITAT POLITÈCNICA DE CATALUNYA  
BARCELONATECH

Escola Superior d'Enginyeries Industrial,  
Aeroespacial i Audiovisual de Terrassa

Bachelor's Degree in Mechanical Engineering

Final Degree Project

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# DESIGN OF AN INJECTION MOULD

## TECHNICAL REPORT

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## 1.- Introduction

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The design of a plastic part is a complex task that requires a deep knowledge of different concepts of materials science, and especially about the particular behavior of plastics both in the molten or solid state. However, one of the main problems associated to the manufacture of plastics components is the need of special tooling such as moulds for the case of the injection moulding process.

The injection moulding process consist in introducing a plastic material in the molten state by means of a pressure inside a mould. The main purpose of the mould is in the one hand to give the shape to the component and on the other hand to cool it until a temperature in which the shape is retained. In this moment, the part is extracted from the mould, usually following an automatic mode.

Plastic components made by injection moulding are usually cheap and are designed for being produced in large quantities. In such a way, the cost of the tooling can be recovered without a substantial increase in the cost of the component. Therefore, mould became a key issue in the manufacture of plastic parts. A well-designed mould should be capable of producing a large amount of parts without requiring extensive maintenance and assuring that all manufactured components are identical in terms of properties.

For this to be ensured it has to follow a very thorough process of design, making sure the parameters set are strictly carried over when fabricating the mould.



## 2.-Objectives

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The main objective of the present project is the design of a mold suitable for producing the T- shaped fitting component at the quality level required by the costumer. This project also includes the design of the T- fitting and the selection of the components required to make the mold. Moreover, a preliminary selection of the plastic family will be also carried out.

The procedure followed to select the different construction solutions for the mold will be also discussed in detail.

Finally, a budget will be realized to evaluate the economic viability of the project, as well as giving information about the amortization of the mould.

### 3.- Scope

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The normal progress of a project like this ends up with the realization of it. Due to the impossibility of doing so because the costs cannot be afforded the project will stop on its hypothetical phase.

The study for choosing materials for the part, the design of the mould and the economical aspects will be carried over, with some guidance for the next steps.

### 4.- Background

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The motivation for carrying out this project is a request from the company KAERCHER, done by the home & garden business division.

The company had been leading the market for over a decade but recently they registered a negative tendency on sales, due to an increasingly competitive market and higher material costs.

To reconduct the negative tendency they are launching a new set of automatic watering system. They have made the whole system lighter, cheaper and more efficient.

The system consists on the following:

Irrigation programmer

Connectors

Hoses

Due to the renewed design they need new connectors and have offered a contract for been provided with 100000 spare parts a year.

## 5.- Part description

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### 5.1-Introduction

A fitting is normally used in pipe systems to connect straight pipe or tubing sections, adapt to different sizes or shapes and for other purposes, such as regulating (or measuring) fluid flow.

Rather than focusing on all the subtypes of fittings, the focus will be on tees. A tee is the most common pipe fitting is used to combine or divide fluid flow. It can be threaded with female thread sockets, solvent-weld sockets or opposed solvent-weld sockets and a female-threaded side outlet, etc. Tees can also connect pipes of different diameters. They are available in a variety of materials sized and finishes. Most common materials include carbon and galvanized steel, impact-tested carbon steel, low-temperature carbon steel, stainless steel, malleable iron, copper, incoloy, ABS, FRP, PVC, HDPE and toughened glass.

### 5.2-Requirements

The main function of the t-fitting will be to connect several hoses. It will be supporting low pressure water ( coming from the pipes ). The part will be supporting 4-5 bar of pressure coming from the pipes. Due to the pressure being low, any of the materials listed above will ensure that the tee will endure the stress generated by the pressure.

### 5.3-Part overview and ubication

The purpose of this T-fitting will be to bifurcate the flow of water coming from the automatic watering system and to connect 3 different hoses enabling the water to arrive to every possible nook.

The part overview is the following:

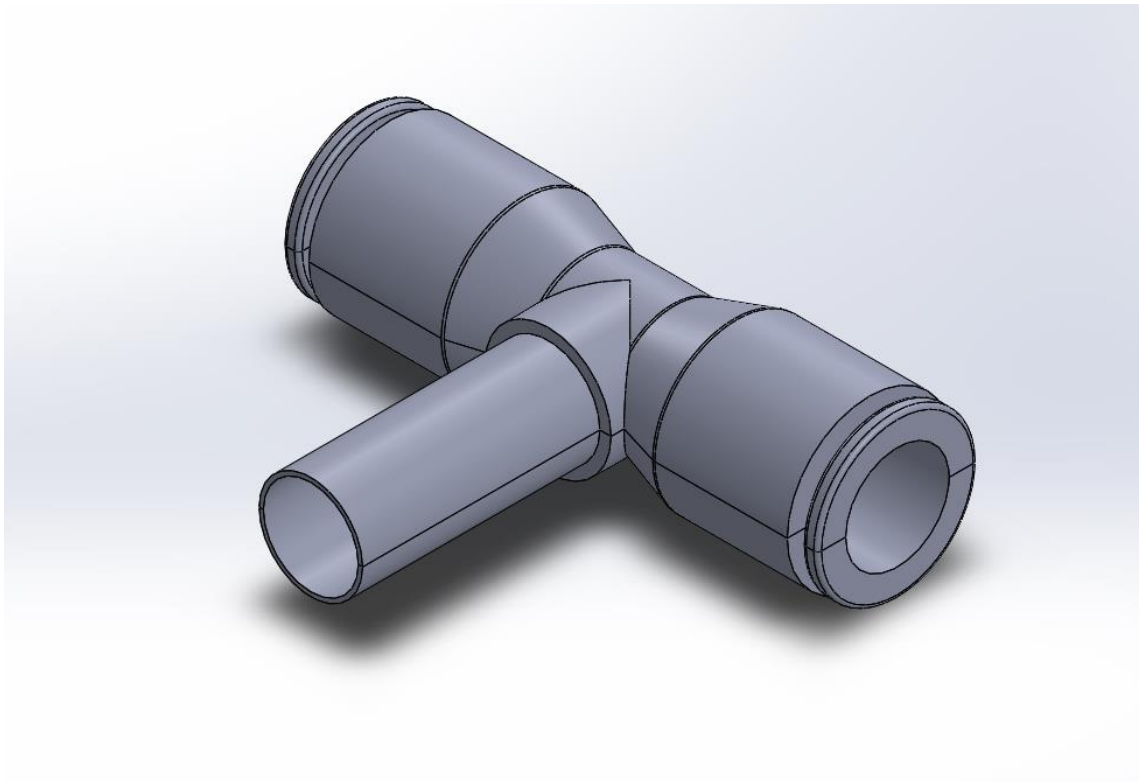


Fig.1 - 3D shape of the part

### 5.4-Requirements for moulding

Before designing the mould it's needed to study the geometry of the part to decide how to ubicate it on the mould.



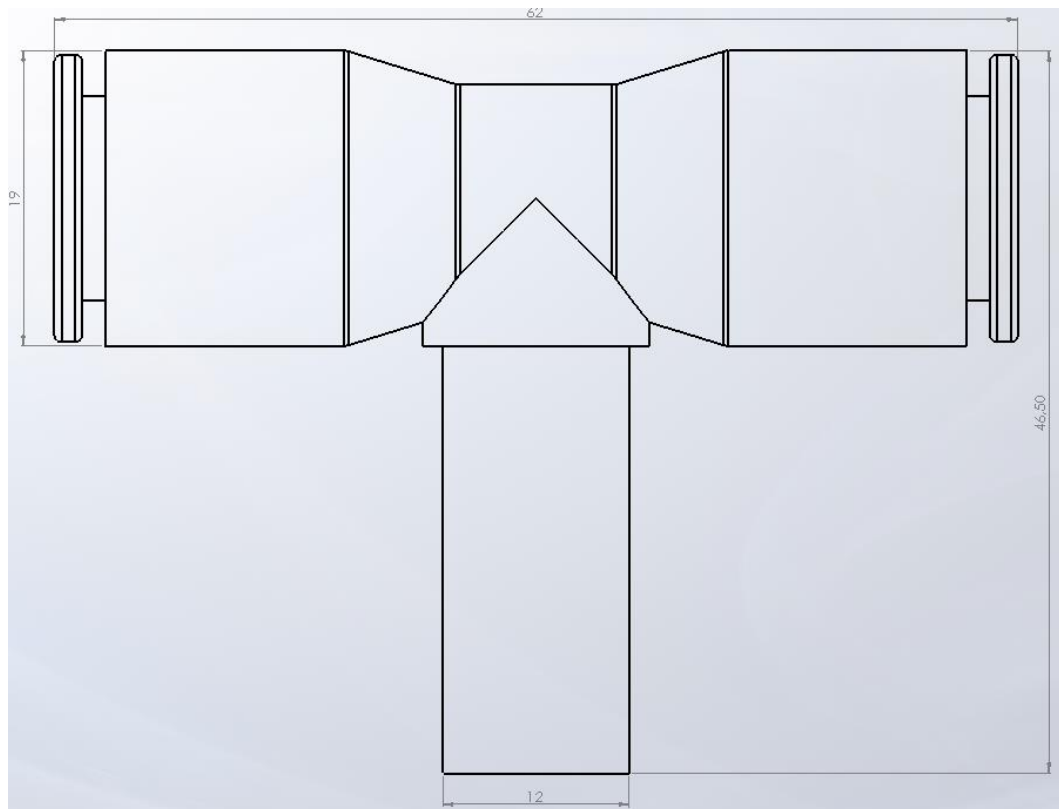


Fig.2 – Part dimensions

With the measurements done the ubication can be set on the mould.

The part is small enough to fabricate several simultaneously.

The layout proposed is a symmetric, 4-part design. Symmetric layouts are simpler to fabricate, since it requires less effort for the worker who will give shape to the mould, because he/she will have less measurements to make.

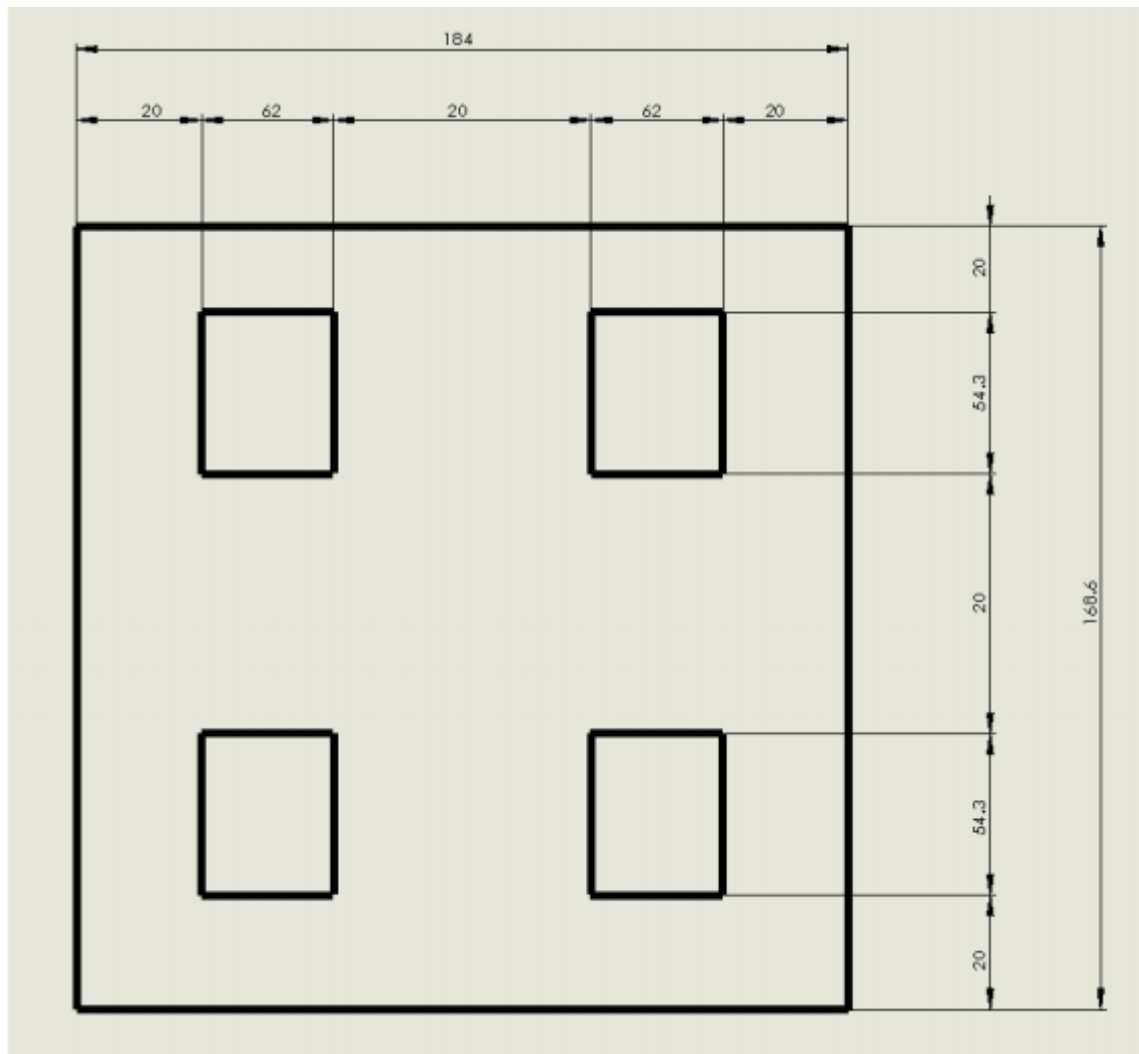


Fig.3 – Layout sketch

The mould will have to be chosen having the dimensions in mind. Also, the mould will have to carry cores, which are covered by the 20 mm on the edges. The runners will follow the symmetric layout and will be located in the middle of the plate.

For being able to fabricate it with an injection mould the partition line needs to be delimited.

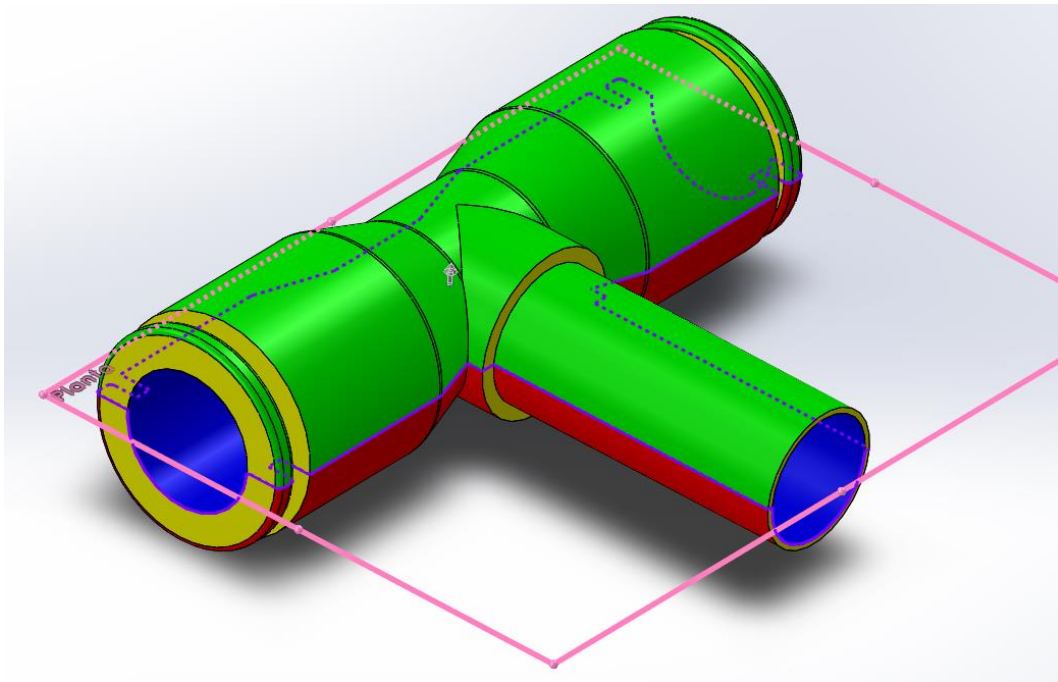


Fig.4 – Partition line

The purple line divides the part in two. The upper part will be static, while the bottom will be the one who moves. When the mold closes it creates the shape desired.

Since it's a hollow part it needs some cores with the inside shape to achieve that.

## 6.- Materials

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The material choosing will be given by the usage of the part.

The actual spectrum of plastic materials is huge, and a ton of ways of classifying them, by its shape, by its internal structure, if they are crystalline, semi crystalline, amorphous, etc.

For this part 3 types of polymers are presented and in the end a decision will be made by evaluating each one of them.

The polymers are the following:

### POLYPROPYLENE BC250MO

- **Description:**
  - Is a very high impact polypropylene heterophasic copolymer intended for injection moulding. This grade is characterized by combination of good stiffness, good creep resistance and very high impact strength even at low temperatures. This grade features high impact strength, high thermal stability and very good processability. As all polypropylenes, this grade shows excellent stress-cracking and chemical resistances.

- **Properties [1]**

**Density**

905 kg/cm<sup>2</sup>

**Mechanical Properties**

Has and toughness. With a flexural modulus of 1100 MPa and tensile modulus of 1200 MPa the polypropylene is a very good material if it has to endure constant stresses.

**Chemical Properties**

It resists: water solutions of inorganic acids, weak organic acids and bleach, some alcohols and some oils.

Is weaker to: strong oxidants, some hydrocarbons and some grades can't be in contact with copper.

## RIGID POLYVINYL CHLORIDE M4820

- **Description:**

- As all the rigid PVS's out there it has extremely high tensile strength, combined with high impact strength due to its high density, availability, cheapness and high flow rate of the material is a really good option. It is also very resistant to chemicals and alkalines.

- **Properties [2]**

**Density**

1300 kg/m<sup>3</sup>

**Mechanical Properties**

High hardness, rigidity and toughness. With a flexural modulus of 2410 MPa a tensile modulus of 2410 MPa and a hardness of 81 on the shore D scale the polyvinyl is a very solid option if high resistance is needed.

### **Chemical Properties**

It resists: salts, bases, fats, acids, alcohols, non-polar solvents and the sunlight if it's well levelled.

Is weaker to: polar solvents, benzene, liquid halogens, sulfuric and nitric acid if they are concentrated.

## **HIGH DENSITY POLYETHYLENE ERACLENE MP90U**

- **Description:**

- Eraclene MP 90 U is a high-density polyethylene homopolymer resin (HDPE) with antioxidants, suitable for injection moulding application. It has a narrow molecular weight distribution and a high density which makes it the perfect choice for manufactures requiring outstanding rigidity, warpage resistance and toughness.

- **Properties [3]**

### **Density**

960 kg/m<sup>3</sup>

### **Mechanical Properties**

It has good hardness and toughness. With a flexural modulus of 1450 MPa and a hardness of 69 on the shore D scale.

### **Chemical Properties**

It resists: diluted acids, alkalis, saline solutions, water, alcohol and gasoline. Under 60° are practically insoluble on every organic solvent.

Is weaker to: strong oxidants.

It absorbs almost no water and has lower water vapor permeability than most of other plastics.

## 6.1.-Material selection

On the next chapter a study for choosing which material to use will be carried over.

The price of each material is a core factor for every decision, before carrying out a study it's a must to know the price of the possible materials.

MATERIAL	COST (€/Kg)	%
PVC	0,875	100
PP	1,2	137,14
HDPE	1,23	140,57

Fig.5 – Table with material price [4]

The fig.3 table presents the cost for each kg of the previously presented materials and the percentage used later to compare them.

The next table will compare several characteristics of each material. A system of rating them between 0 and 3 is settled down. 0 means no good and it goes up until 3 which is very good. Then a degree of importance is established from 1 to 10. With these scales and applying a simple operation of multiplying the 0-3 with the 1-10 and then doing the sum a number telling how good the material is considered for this project.

MATERIAL	DEGREE OF IMPORTANCE	PVC	PP	HDPE
characteristics				
Easy to inject	9	3	3	3
Chemical resistance	6	2	1	1
Toughness	7	3	1	2
Hardness	5	3	1	2
Density	9	0	2	3
Price	9	3	1	1
Easy to recycle	7	2	3	2
QUALITY SCORE		116	93	107
COST (%)		100	137,14	140,57

Fig.6 – Material comparison table

PVC seems to be the go to material, following the fig.4 data. But to push a bit further, 2 graphics will be presented to smooth the choosing.

First graph shows the quality score vs material and the second one the quality vs cost.





Fig.7 – Quality vs material graphic

The actual two materials that can go on are PVC and HDPE.



Fig.8 – Cost vs quality graphic

The material chosen is PVC.

## 7. Mould design

The next section covers the design of the mould from the beginning.

There is a great variety of type of moulds depending on the cast, the ejection system, the part geometry, etc.

The mould has to be capable of producing the shape of the chosen part.

The key factor is the shape of the part because it will determine the rest of the mould. On this particular case, a T-fitting will be produced.

For doing that an injection mould has been chosen.

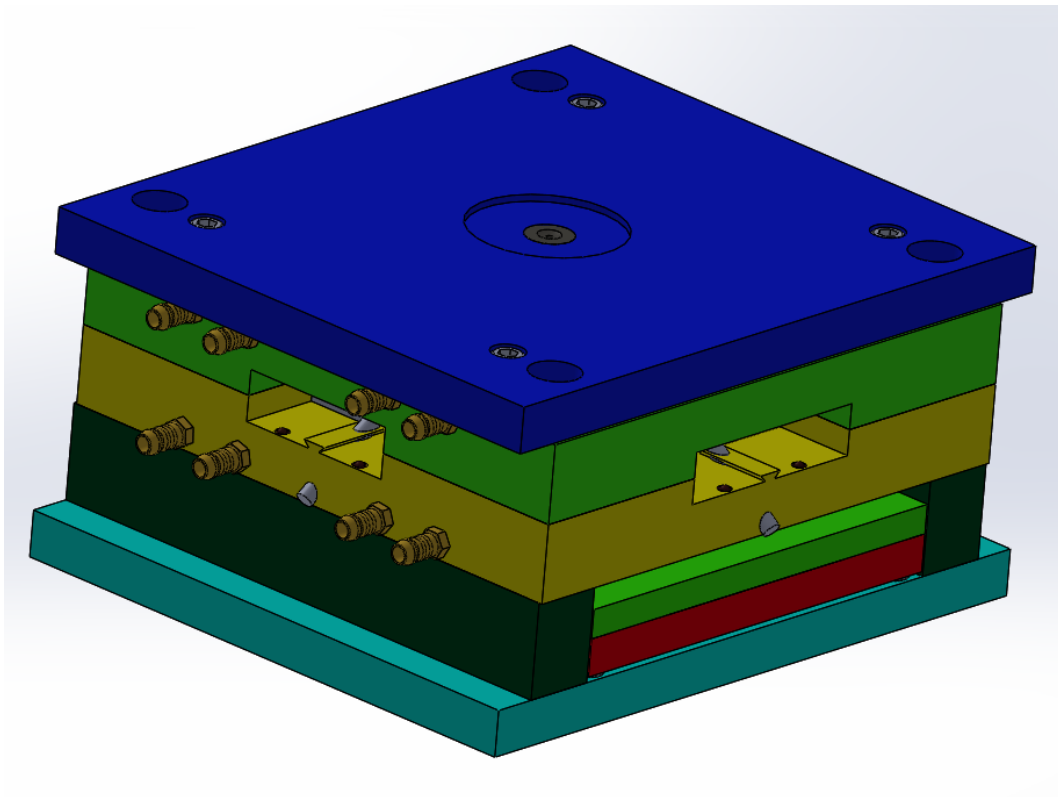


Fig.7 – Mould overview

The first thing to notice is the cores incorporated that are needed for making the part hollow. The cores move horizontally when the mould opens, leaving the desired hollow shape to the part.

### 7.1.- Part ubication

The first layout had a problem and was that the 20 mm space between the cavities and the end of the mould was not enough for the cores to slide without falling down, so a much bigger mould had been chosen.

The mould is designed to fabricate 4 parts on a single injection cycle. The part dimensions make this possible. Square dimensions have been chosen for keeping it as symmetric as possible, making it easier to mechanize.

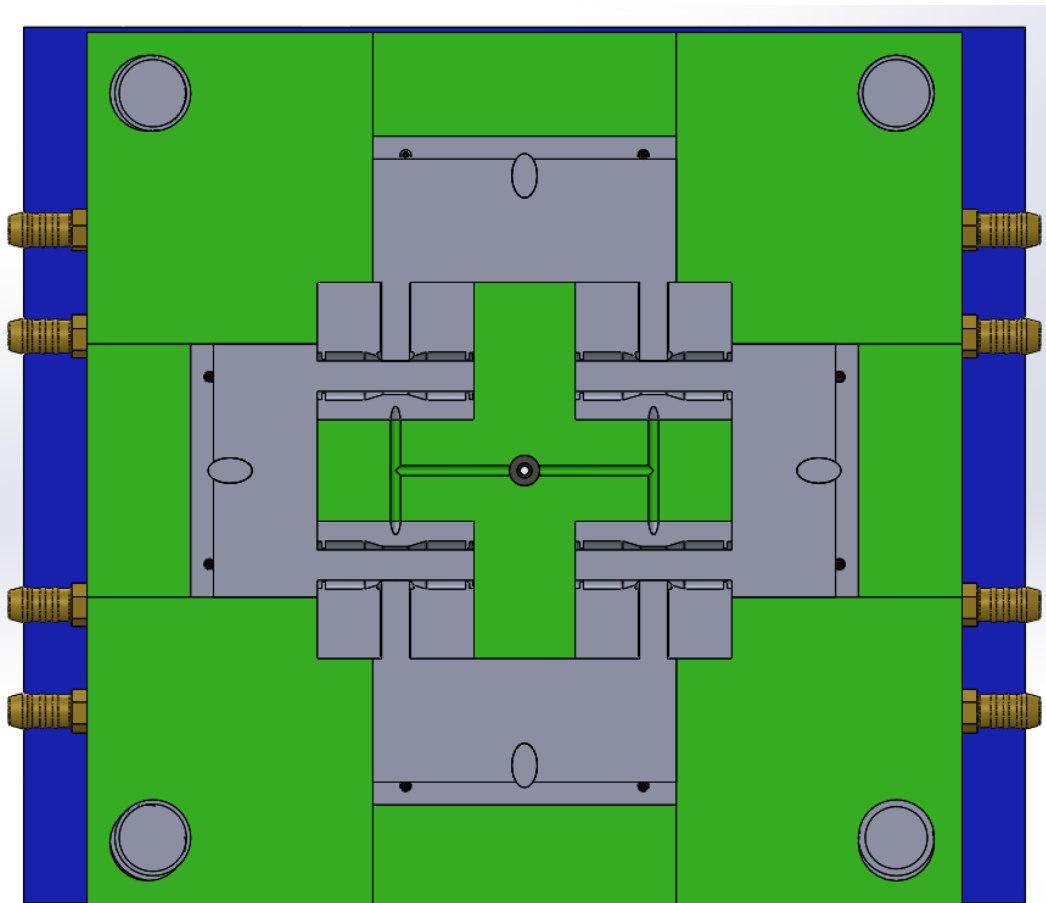


Fig.8 – Part distribution

On fig 8 the 4 cavities for the part can be observed. The reason the cavity has different color is because the mould has been designed to not only be able to produce one type of T-fitting, but a range of different values of them. So, it will be able to make more profit than if it only produced one specific type.

Just by changing the cavity it's possible to make another part (always keeping in mind the geometrical restrictions).

The part is located on the cavity, and then this cavity is brought to the mould as seen on fig 9.

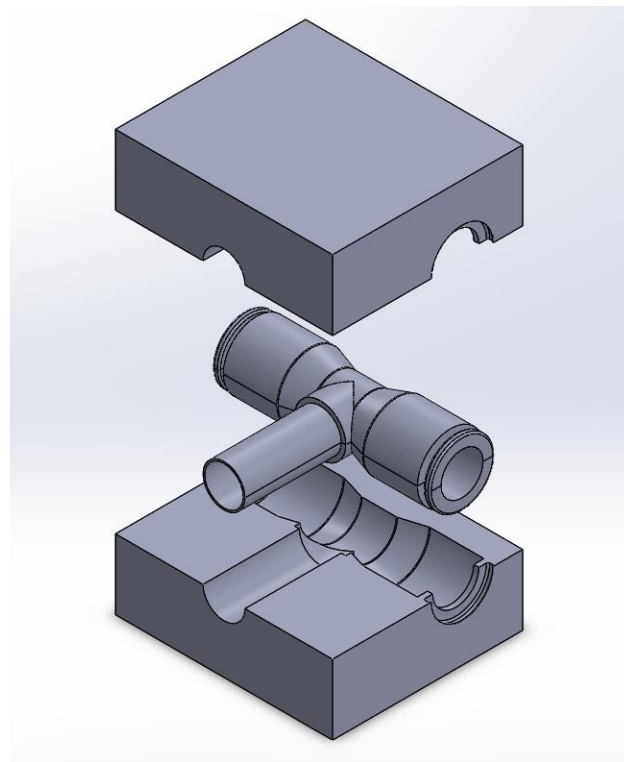


Fig.9 – Part cavity

## 7.2.- Mould cycle

On the next lines the cycle which the mould goes through will be described.

### 7.2.1.- Initial position

First the mould remains closed, as observed on fig. 7 and ready to inject the PVC.

### 7.2.2.- Injection

The flow, temperature, pressure, velocity... is controlled from the injection machine. The PVC coming from the injection machine flows through the sprue (red color),

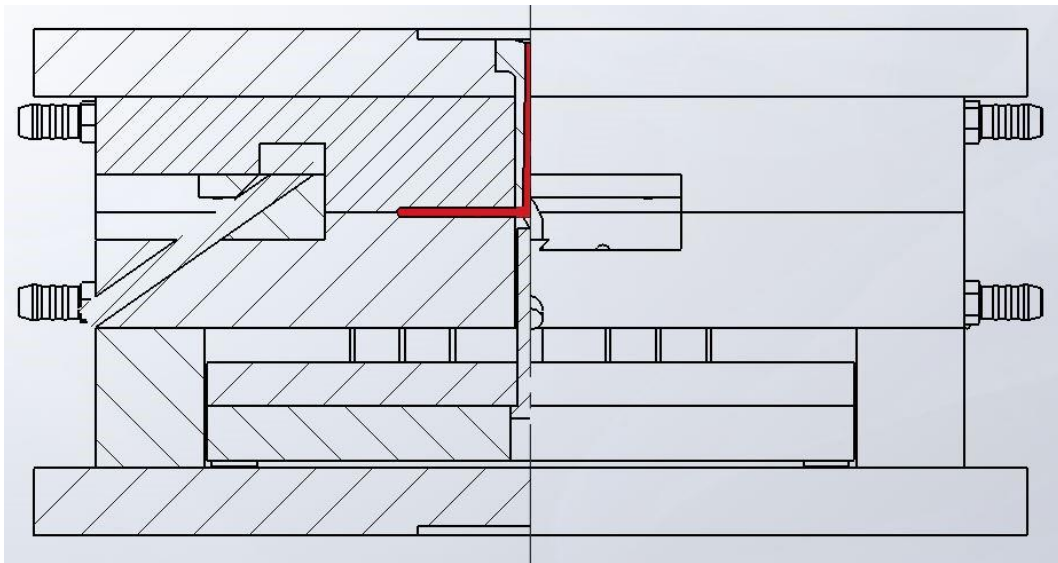


Fig.10 – Molten PVC flow through sprue

from it to the runners,

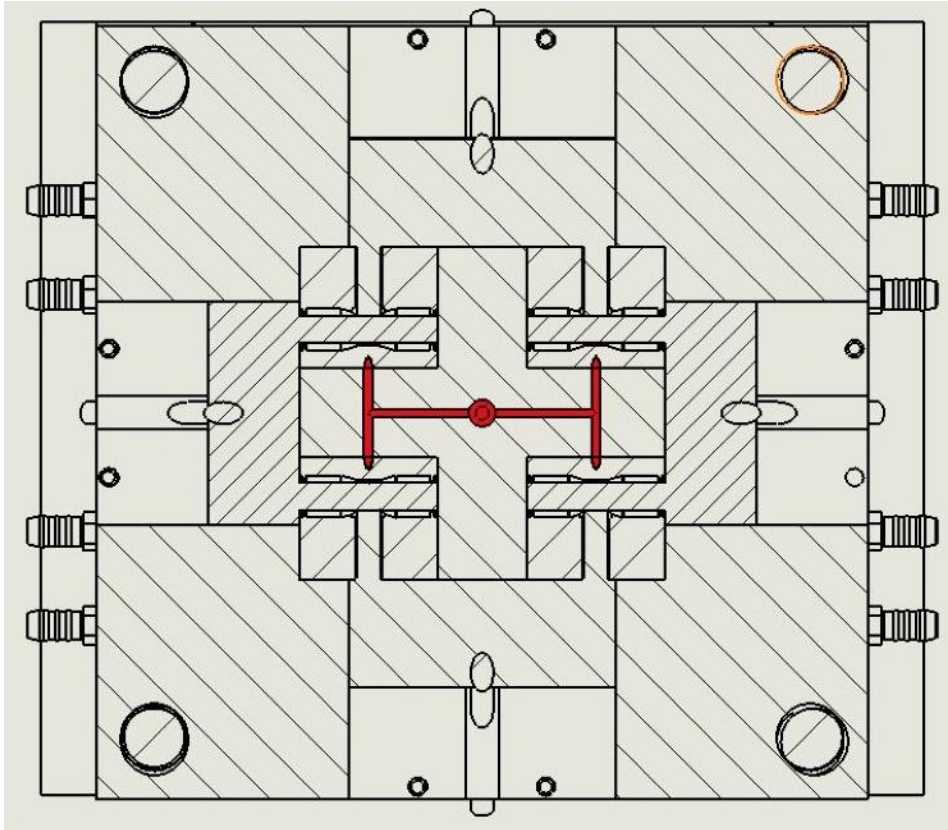


Fig.11 – Molten PVC flow through runners

the gates and finally to the cavities as seen on fig. 10, 11 and 12.

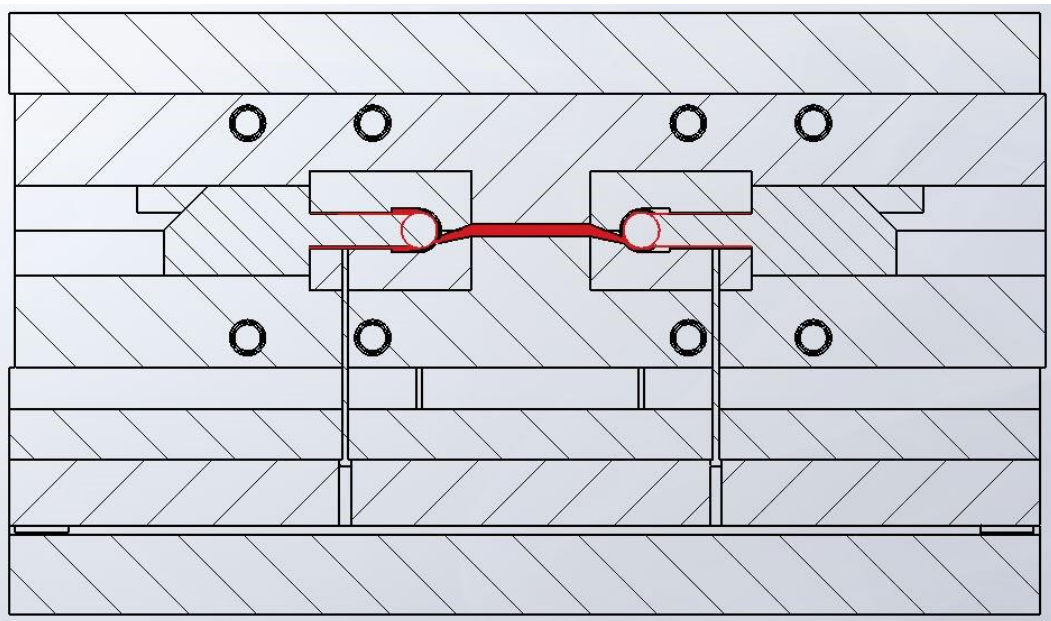


Fig.12 – Molten PVC flow filling cavity

When the molten PVC starts to flow so does the cooling system, pumping water to control the temperature on the mould.

### 7.2.3.- Mould opening

After injecting the material into the cavity and waiting enough for it to cool down the mould opens from the middle plates, at the same time the cores start also moving, leaving behind the part shape, until its full opening (fig 13).

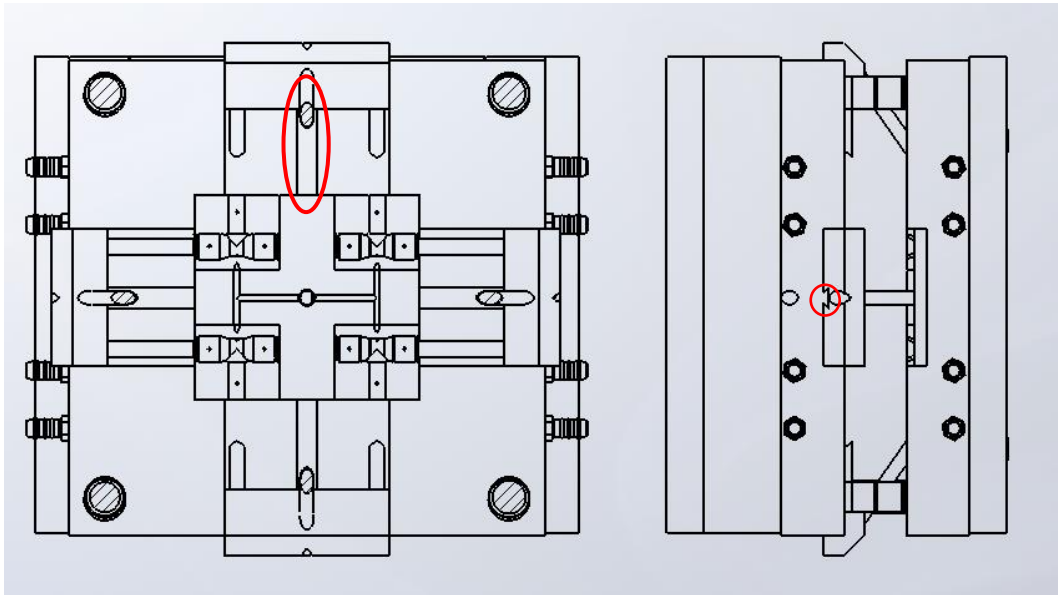


Fig.13 – Mould cores opened

The cores slide through a positioning channel (red circles) which ties them to the bottom plate.



Also, for every core there are 2 spring plungers (fig.14) that delimitate how far the cores can go,

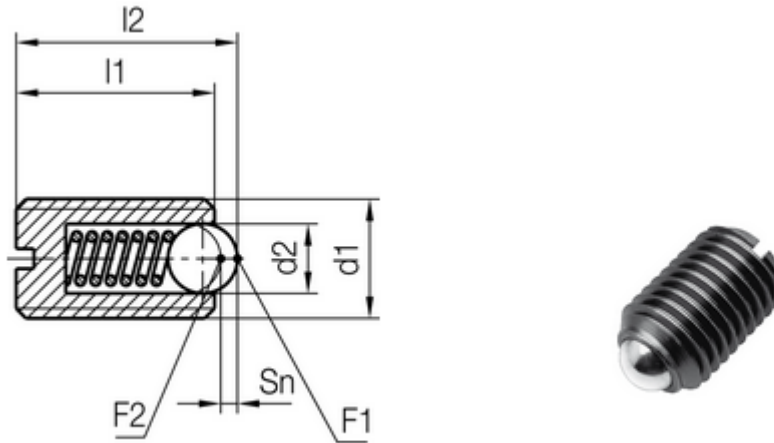


Fig.14 – Spring plungers

the cores have holes mechanized with the form of the spring plunger as well, so when they make contact the dock of the spring plunger goes up and nail the part. The bottom plate also has drills to allocate the spring plungers (fig. 15).

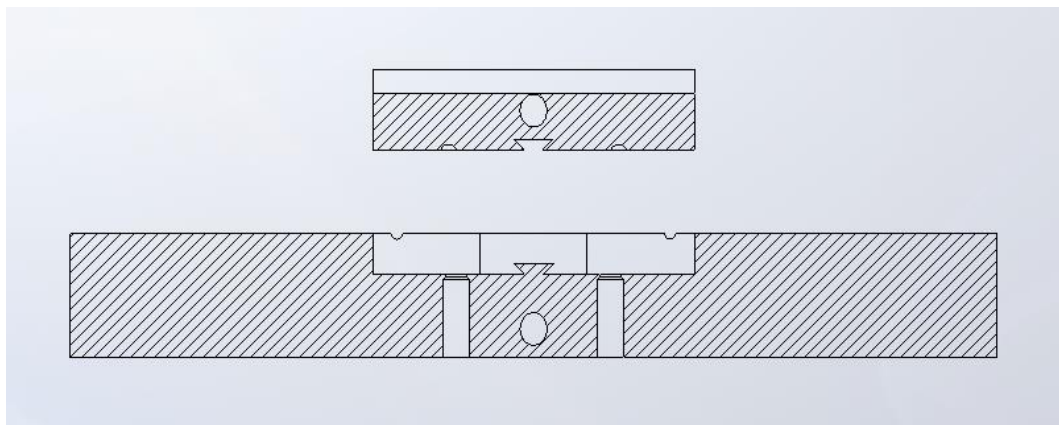


Fig.15 – Spring plungers housing



### 7.2.4.- Part ejection

When the mould opens completely and the cores are out of the cavities the ejector pins come up and separate the part from the mould.

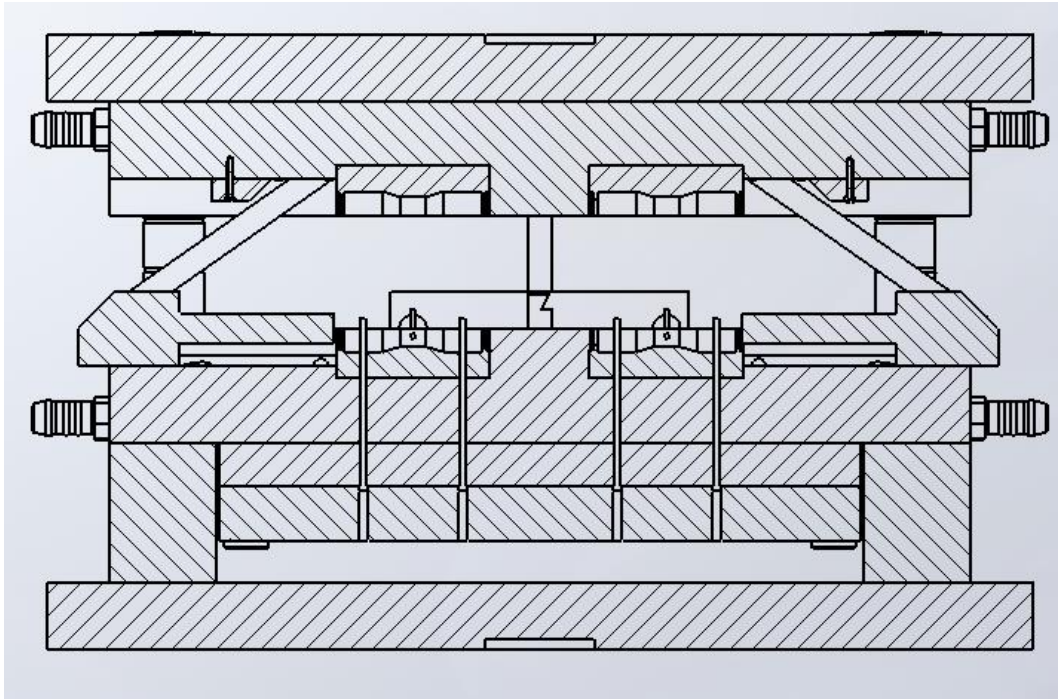


Fig.15 – Spring plungers housing

There is a total of 3 ejector pins for each cavity. The middle ejector pin has triple function, first one is to eject the sprue, the second one is to prevent the sprue and runners from falling. The mould will be horizontally positioned, so if no action was taken, once the ejector pins come out the 4 connected parts by the sprue would fall into the ground, by notching the middle ejector we can make sure it will remain there. And last, it breaks the gates leaving only the desired part shape. This is thanks to the design of the gate, the gate is pitched and thinner on the end, which helps break it.

### 7.2.5.- End of cycle

The parts are grabbed, the mould closes and begins the cycle again.  
They will look something like fig 16.

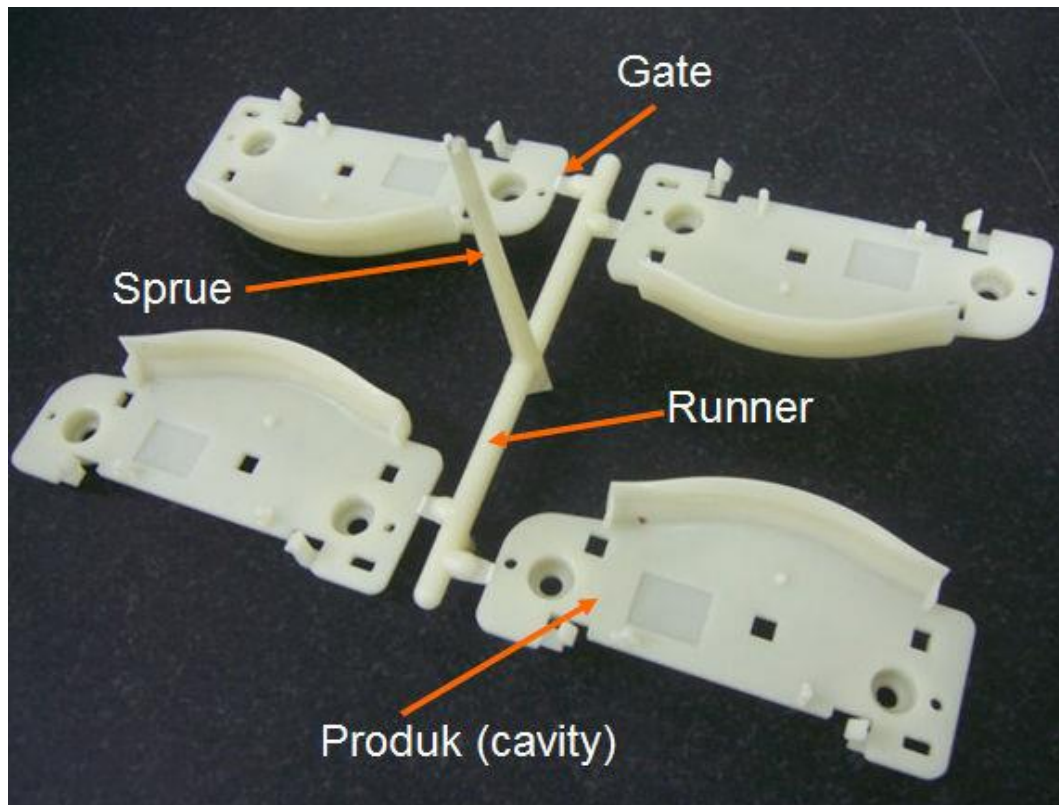


Fig.16 – Similar injected parts [5]

### 7.3.- Casting system

The casting system used on this mould is a cold casting system. The reason behind this is because it's simpler than a hot casting system, it's cheaper and easier to do the maintenance. The drawback is that we will have solid waste if we are not able to recycle it for injecting it again, but the pros are good enough to go for this casting system.

The casting distribution also plays an important role here. A good layout can help reducing the waste. In this particular case, for four cavities, a symmetric layout has been chosen.

### 7.4.- Cooling system

The part cavity is surrounded by cooling channels made on the middle plates. Having control of the temperature is key on injection moulding to avoid problems like excessive contractions whose produce deformations on the part.

The diameter of the channels is given by the thickness of the part. In this case the thickness is very thin, therefore, a generic value that can handle multiple thickness had been set. The value is showed on the planes P2 and P3 for top plate and bottom plate respectively.

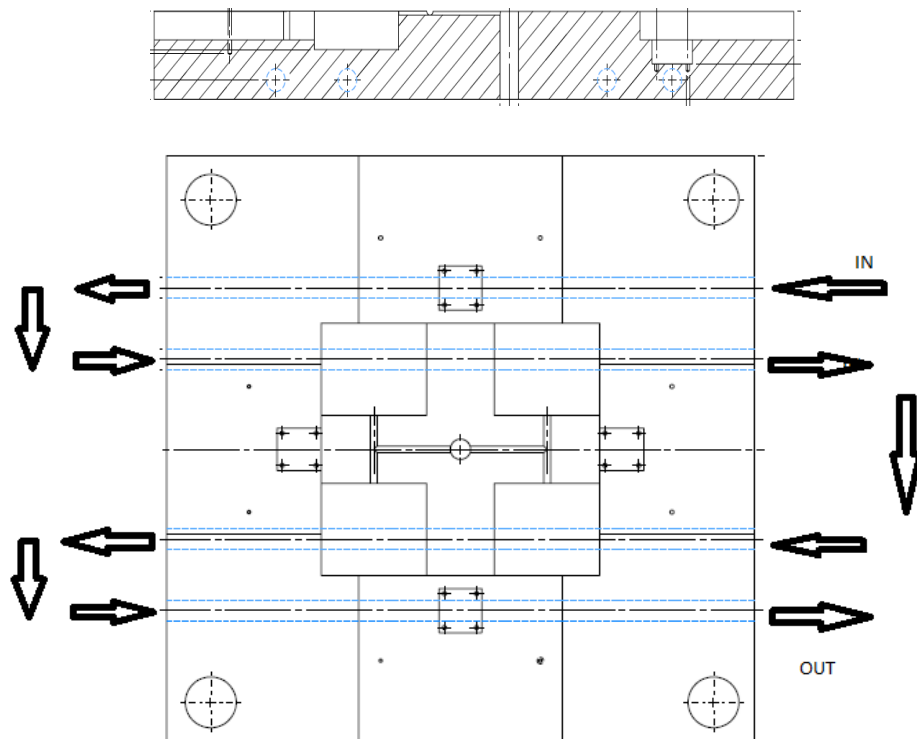


Fig.10 – Cooling circuit

The refrigeration circuit are drill holes through all the middle plates, and below the cavities as seen on fig 10. On each hole (beginning and end) there is a hose plug (fig 11) for connecting them and make the water flow through the mould.

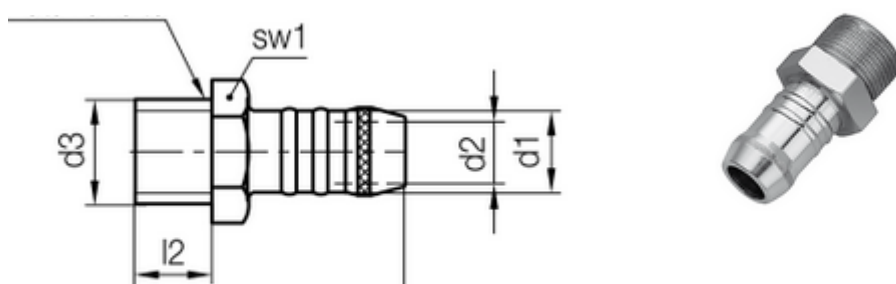


Fig.11 – Hose plug

The hose plug is normalized and can be bought to the supplier directly.

## 8.- Environment

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Nowadays plastics are everywhere, their relation between mechanical properties, cost of production and weight are unmatched.

The wide usage of plastics makes the environmental consideration a must when dealing with them. Sadly, plastics are not ecologic friendly, but just when it comes to recycle the material as that, the rest of the process is not energy consuming as to molten steel for example. Also, the machinery doesn't suffer the same when dealing with plastic as it does when dealing with ferrous materials. The engines and machinery consume more, leading to wear down before and to change machinery more often, which consumes natural resources and energy to be fabricated, so maybe on the overview they are hand to hand with steel (which is the other wide used material) when comes to polluting.

Therefore, it's treatment after the life span has to be detailed and carefully supervised to avoid massive storage of waste.

The project will have to give instructions for the recycling of the PVC and the material used for mould fabrication.

Concerning the mould, once it ends its useful life it will have to be cleaned, disassembled and its recycling parts selected.

Concerning the plastic wastes, we can divide them into two groups:

1. Internal waste: The waste that will be produced by fabricating parts, for example runner and sprues.
2. Defectives: The waste generated by quality, the parts not passing the test and the parts returned by the customer.

Due to not being the final costumer (it will be KAERCHER in this case) the control of the final waste that will be when the part has ended its usefulness, or has broken, etc. it will be difficult to control the recycling, but it will be pointed out the desire to recycle them if possible.

Luckily, PVC is a very well-known material and its recycling process has been getting better through the years.

The PVC is easily recyclable, and when recycled it has a wide range of applications. In fact, its recycling is as old as its fabrication.

Thanks to its thermoplasticity and being easy to transform, PVC can be recycled with the following processes:

- Mechanical recycle: Most used process. The waste is milled, additives put back (if needed), and transformed again into products.
- Chemical recycle: The waste is brought under chemical processes, under controlled temperature and pressure for decomposing them into more elemental products such as grease and oils. It's a very high-technological process and currently it's only applied on very developed countries.
- Power recycle: Consists on the controlled burning of the waste to recover some of the energy restrained on it.
- Solvent recycling: It consists on the chemical dissolution of PVC through solvents like Vinyloop.

The case we concern about is the mechanical recycling. Supposing the place where the parts are fabricated have the machinery to recycle with this method it will be carried over on the spot because it saves buying a lot of raw material. If not, the waste will have to be managed by a third-party company.

## 8.- Conclusions

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On this project, an injection mould capable of producing 4 part/cycle has been designed.

The mould has been designed by following the needs flow. The need was to produce 10000 of these parts, which this mould can do in more or less a month.

It also can produce other type of parts (always considering the geometrical restrictions), which can possibly make recovering the investment much quicker.

## 9.- Bibliography

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### Catalogs

- The Hasco catalog. For mould components price.
- Borealis catalog. For polypropylene properties.
- PolyOne catalog. For PVC properties.
- Eni Versalis catalog. For polyethylene properties.

### Websites

- <https://www.youtube.com/watch?v=dWZumei9-zQ> :
  - [Consulted on the 22/04/18] Videotutorial for splitting parts on Solidworks
- <https://www.hasco.com/hasco/es/formAssistant>
  - [Consulted on the 21/03/18] For downloading the mould CAD mould
- <https://www.creativemechanisms.com/blog/everything-you-need-to-know-about-pvc-plastic>
  - [Consulted on the 10/05/18] PVC information.
- <https://www.pitfallsinmolding.com/cycletime.html>
  - [Consulted on the 18/05/18] Information about cycle time and cooling.



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- <https://todopolimeros.wordpress.com/2017/03/15/colada-fria-colada-caliente/>
  - [Consulted on the 25/05/18] Information about types of casting systems.
- <http://www.matweb.com/>
  - [Consulted on the 12/05/18] Information about materials.
- <http://tecnologiadelosplasticos.blogspot.com/2012/10/reciclado-de-pvc.html>
  - [Consulted on the 28/05/18] Information about PVC recycling.

## Books

- Menges, Georg, (2001), *"How to make Injection molds"*, Munich: Hanser, Gardner Publications

## References

[1]-Properties from Borealis catalog.

[2]-Properties from PolyOne catalog.

[3]-Properties from Eni Versalis catalog.

[4] Prices from plasticker, t.h.o.p., monatspreisubersichten.2017

[5] Image courtesy of the user Blue tooth7, published on the 14 October 2011 under the Creative Commons Attribution-Share Alike 3.0 Unported license on [https://commons.wikimedia.org/wiki/File:Mold\\_cavity.jpg](https://commons.wikimedia.org/wiki/File:Mold_cavity.jpg) .



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# DESIGN OF AN INJECTION MOULD BUDGET

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## 1.- Introduction

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The budget for creating the injection mould designed on the technical report will be realized. The budget will include materials, machining, assembling and designing.

An assessment of the costs will be done and the cost for fabricating the 10000 will be calculated.

DISCLAIMER: Without working on a company dedicated to the sector there is no way to give exact prices, so the ones showed may be not the final ones. They normally include some sort of discount reached after both interested parts meeting.

The budget will be break down into subsections for facilitate its understanding. First the cost of the normalized mould components, then the costs of machining the components, creating the new ones and applying thermal treatments, after that, the assembly of all components and finally the design costs.

## 2.- Mould components

There are a lot of mould components providers on the market. On this case Hasco has been chosen among all of them for its assistant, which is very intuitive and easy to use. They also provide CAD data for all its components without the need of registration.

Code	Price/u (€) *	Quantity	Material
Z31_12x85	1,12	4	DIN 912
Z31_8x30	0,26	4	DIN 912
Z31_12x30	0,57	4	DIN 912
Z31_2x16	0,22	24	DIN 912
Z33_4x8	0,28	4	DIN 7991
Z691_12x2,5	0,09	8	-
Z55_18x3	1,76	4	DIN 1.0711
Z00_46x22x65	21,53	4	DIN 690
Z10_46x24	17,54	4	DIN 690
Z20_30x60	8,48	4	DIN 690
Z40_2x100	2,98	12	DIN 1530
Z40_10x100	6,24	1	DIN 1530
Z87_13x12x1.5	0,98	16	DIN 2.0401
Z511_12x56x3,5x15,5	46,77	1	DIN 16752
Z37_10x19	0,75	16	DIN 1.0718
K10_346x346x27	366,67	2	DIN 1.2379
K20_246x246x46	518,21	2	DIN 1.2379



K40_346x346x56	117,29	1	DIN 1.2379
K60_346x346x17	180,80	1	DIN 1.2379
K70_346x346x22	216,74	1	DIN 1.2379
<b>TOTAL</b>		<b>2606,43 €</b>	

2606,43 € is the cost of the components directly bought to Hasco.

The plates have been ordered on quality 2379 because is a high hardness steel and can be applicated the quenching and tempering heat treatment.

There are components not appearing on the table and it's because those can't be bought, they must be mechanized, thus will be included on machining costs.

### 3.- Machining

---

Once the parts are acquired they are sent to machining for obtaining the desired dimensions on the components.

Nowadays almost every mould is built by EDM (Electrical Discharge Machining) and CNC (Computer Numerical Control) machining.

Those two methods allow to give the most complex shapes to moulds with a lot of precision and efficiency, since they are driven by computers.

The prices given below will be for CNC machining. The price is 54 €/h [1].

The table below shows the number of minutes needed to give shape to the components brought directly from the supplier and the cost of machining.

Code	Quantity	Minutes	Cost (€)
K10_346x346x27	1	50	45
K20_246x246x46-t*	1	4200	3780
K20_246x246x46-b*	1	4800	4320
K60_346x346x17	1	70	63
K70_346x346x22	1	70	63
<b>TOTAL</b>			<b>8271 €</b>

\*t:top plate, b:bottom plate

The operations needed are detailed on the planes.

For the non-standard components buying the raw material will be needed. The material chosen is steel 2379 because is a high hardness steel and can be applicated the quenching and tempering heat treatment.

The price is 3,5 €/kg. [1]

The amount of material each component has is:

- Frontal ejector- 1,26 kg, 2 u
- Side ejector- 0,94 kg, 2 u
- Sliding guide- 0,13 kg, 4 u
- Shingle- 0,17 kg, 4 u
- Top part housing- 0,90 kg, 4 u
- Bottom part housing- 0,45 kg, 4 u

Total: 11 kg

The amount of material needed is calculated by the designing 3D software SolidWorks by grabbing the volume and then multiplying by the density of steel 2379. [2]



The amount of steel needed is really low and it will be included into the budget given by the workshop where the components will be brought. Also, it won't have much impact on the final price by the reason given above. It will be omitted from the final price.

The table below shows the number of minutes needed to give shape to the components that can't be brought directly from the supplier and the cost of machining.

Code	Quantity	Minutes	Cost (€)
Frontal ejector	2	200	360
Side ejector	2	200	360
Sliding guide	4	40	144
Shingle	4	30	108
Top part housing	4	150	540
Bottom part housing	4	150	540
<b>TOTAL</b>			<b>2052 €</b>

The total cost from machining is **10323 €**.



## 4.- Assembly and adjustment

---

After machining comes the assembly and adjustment. This process ensures that the mould will work as we want for injecting.

It also ensures that the dimensions are the ones settled on the planes.

The approximate hours dedicated to this are 50 hours. Each hour of assembling and adjustment cost around 45 €. [1]

The total cost for assembly and adjustment is **2250 €**.

## 5.- Thermal treatments

---

When the parts have been assembled together they are driven to have thermal treatment.

For thermal treatments, only quench and temper will be considered since the quality of the parts is enough to ensure proper functioning of the mould.

Quench and temper is a thermal treatment that consist in heating the part until it reaches a desired temperature, and then cooling it down.

The first part (quench) hardens the material a lot, but it also makes it very brittle. That's the reason we temper right after, to take a bit of that hardening in order to take a big chunk of that brittleness away.

The price of quench and tempering is given by the weight of the components that we are going to heat. The price is approximately 2,5€/kg for steel 2379. [1]



The table below shows the amount of kg and the price for each component.

Code	Quantity	Weight (Kg)	Cost (€)
K10_346x346x27-t*	1	3561,87	68,6
K20_246x246x46-t*	1	4268,02	82,2
K20_246x246x46-b*	1	4282,44	82,5
K40_346x346x56	1	1473,52	28,4
K60_346x346x17	1	1513,11	29,2
K70_346x346x22	1	1945,25	37,5
K10_346x346x27-b*		3571,09	68,8
Frontal ejector	2	2,52	12,6
Side ejector	2	1,88	9,4
Sliding guide	4	0,52	5,2
Shingle	4	0,68	6,8
Top part housing	4	3,6	36
Bottom part housing	4	1,8	18
<b>TOTAL</b>			<b>416,6€</b>

The total cost for thermal treatments is **416,6 €**.



## 6.- Designing costs

---

This work usually comes under the radar, but the hours spent on designing the mould are no joke and they have a price.

It has to be done by a technician with experience on the sector. A good design is key for ensuring that the mould will work fine, since it will avoid later problems, that translate into money saving.

The amount of time dedicated to this phase have been almost 200 h. The hour of design is more or less 25€.[1]

The total cost for designing is **5000 €**.

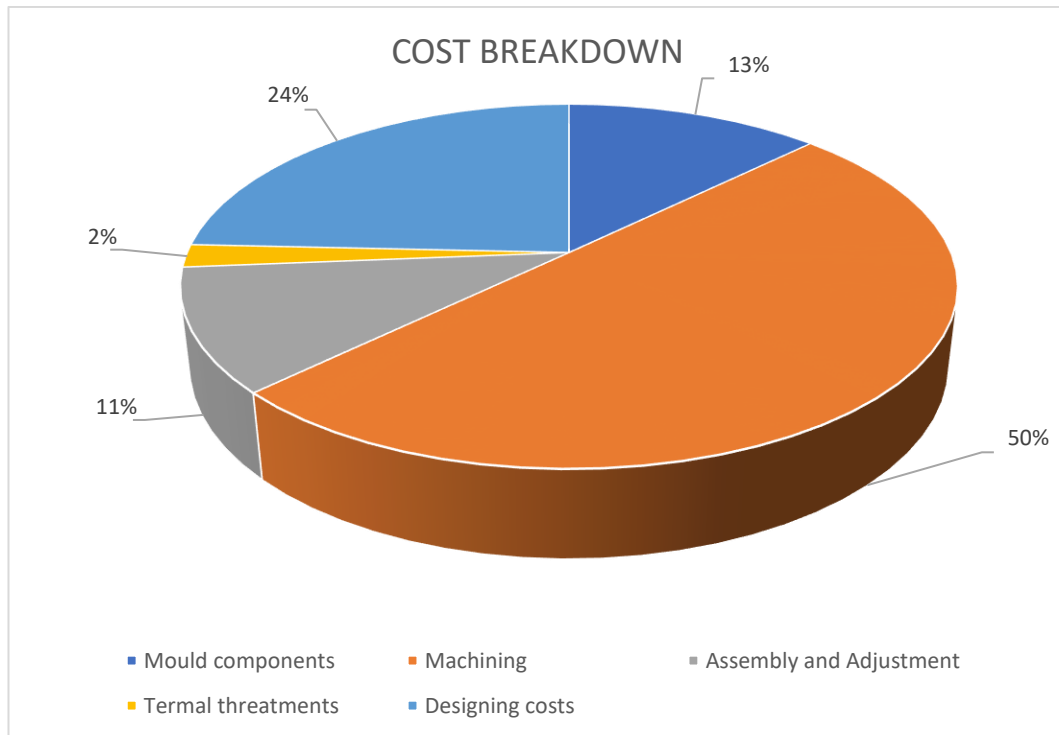
## 7.- Budget resume

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NAME	AMOUNT (€)
MOULD COMPONENTS	2606,43
MACHINING	10323
ASSEMBLY AND ADJUSTMENT	2250
TERMAL THREATMENTS	416,6
DESIGNING COSTS	5000
<b>TOTAL AMOUNT</b>	<b>20596,03</b>

## 8.- Assessment

The results will be discussed on the following chapter.



As we can see on the graphic above, most of the cost of the mould is machining. It is no surprise, since we must create parts from 0 and the middle plates need a lot of machining. The second is designing, with 26% of the cost of the mould. Next, we have the components and the assembly and adjustment with 13% and 11%. The reason the mould components are cheaper than designing cost is that the mould isn't very big, so the components aren't very expensive. Finally, we have the thermal treatments, with the 2% over the total cost of the mould, as said above, the mould isn't very big and the thermal treatments are paid by weight, so if the mould isn't big it won't weight much and the cost for quenching and tempering will be small.



## 9.- Unitary cost and amortization

---

This chapter will try to calculate the amount of money needed to fabricate one part, and then the amortization of the mould itself.

### 9.1- Material cost

The type of casting is cold casting, meaning that on every cycle waste will be produced. Each cycle will produce 4 parts. For calculating the money needed for each cycle some data is required:

- Total volume needed on each cycle:  $1,27 \times 10^{-5} \text{ m}^3$
- Density:  $1300 \text{ kg/m}^3$  [3]
- Price:  $0,875 \text{ €/kg}$  [3]

Operating, each cycle has an approximate cost of **0.014€**, only from raw material (PVC).

### 9.2.- Injection machine costs

The costs of the injection process involve the amount of money the injection machine is consuming each hour, which varies if the injection is made on a machine the company owns or has to subcontract the production. On this case the company will own the injection machine. The total price can be calculated with time each cycle has and the total number of parts needed to fabricate.

- Estimated time for each cycle: 30 secs.
- Cost of the injection machine:  $30 \text{ €/h}$  [1]
- Target number of parts to produce: 100000 parts

Operating, producing the 100000 parts will cost **6250 €**.



### 9.3- Total cost

The total cost for producing the 100000 parts will be the sum of injection moulding machine costs and the cycle cost multiplied by the cycles required to fabricate 100000 parts.

NAME	AMOUNT (€)
RAW MATERIAL	350
INJECTION MACHINE	6250
<b>TOTAL AMOUNT</b>	<b>6600</b>

Once total cost is calculated the unitary cost can be known.

Operating, the unitary cost of fabrication is  $\cong 0.07 \text{ €/u}$ .

The unitary cost is useful to set the price desired having into account all economic variables, such as profit margin, fixed costs, etc.

### 9.4- Amortization

The amortization of the mould depends on how much time it's wanted to be amortized. In this project the calculus will be for amortizing the mould on 1 year.

Each year the mould will fabricate the 100000 parts, with the total cost for fabricating them and the total mould cost, the unitary price a part has to be sold to is set.

Operating, each part would have to be sold by minimum  $\cong 0.28 \text{ €}$ .

This result needs also to contemplate a 40% of profit margin, 20% of fixed costs and 16% IVA. [1]

Operating, the part should be sold each one for **0,5 €**.



## 10.- Working time

---

The following section will try to calculate the time dedicated to produce the part goal that is 10000 parts/year.

For doing that few data id needed to know:

- Cycle time: Approximately 30 secs
- Parts/cycle: 4 parts
- Working hours: Theoretically the working day has 8 hours.

Operating we have that we can produce up to 3840 parts each day.

For producing the 100000 parts we will need at least 27 days, which is more or less a month (of working, not including weekends or festivities).

As said on the technical project, if the cavities change it can produce other parts, so it can work 27 days for having the 100000 parts ready and then work for other projects, making it easier to amortize.





## 11.- References

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[1] The prices and the number of minutes needed for machining and thermal treatments with the price of raw material are given by the workshop workers of ThyssenKrupp Materials Iberica. Thus, they are an approximation since the components have not being produced.

[2] Density from BLOCK Y CIA S.A.C.I. catalogue. Steel F2379

[3] Density and price from technical memory, chapter 6, pages 11 to 14.



UNIVERSITAT POLITÈCNICA DE CATALUNYA  
BARCELONATECH

Escola Superior d'Enginyeries Industrial,  
Aeroespacial i Audiovisual de Terrassa

Bachelor's Degree in Mechanical Engineering

Final Degree Project

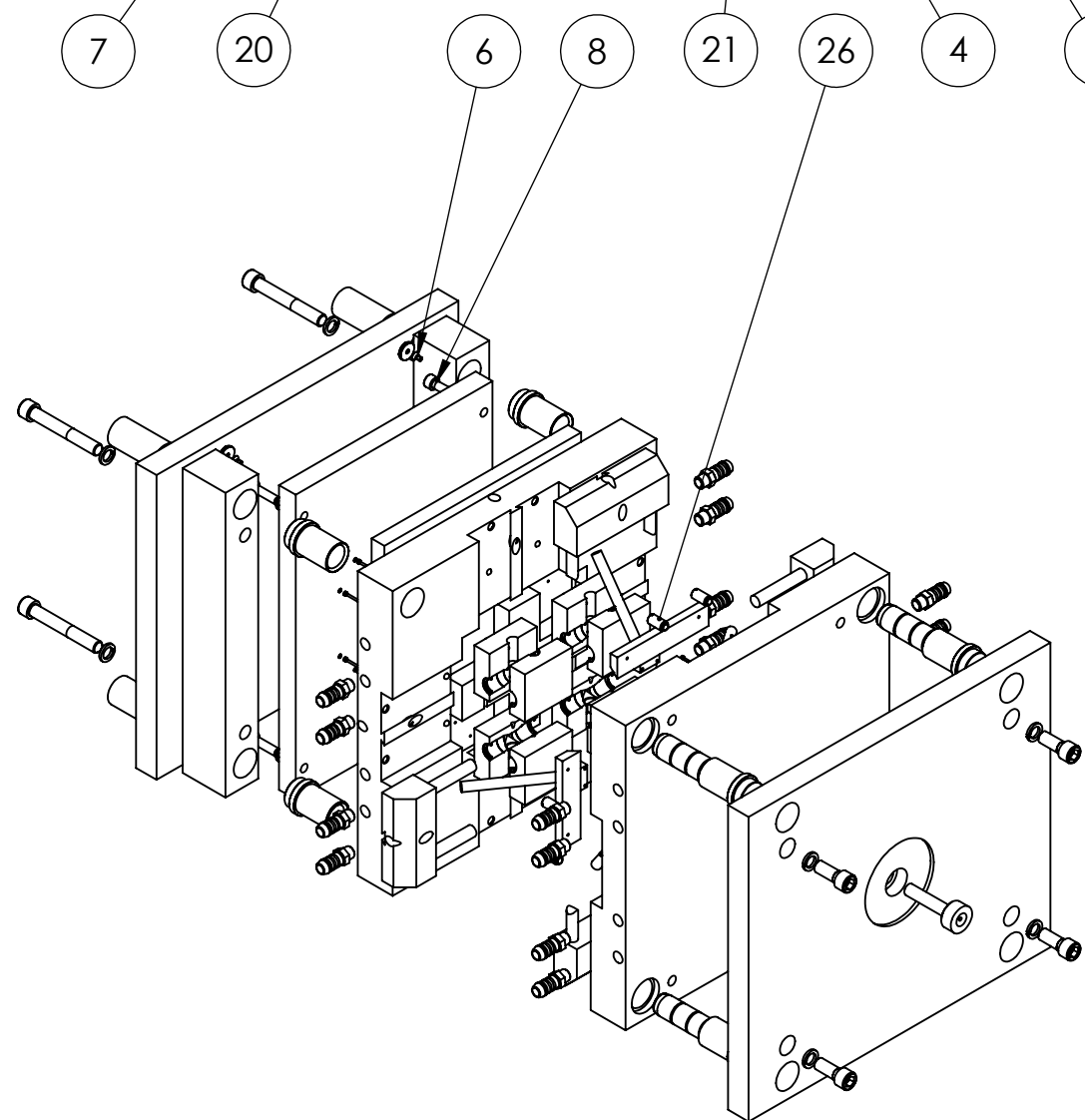
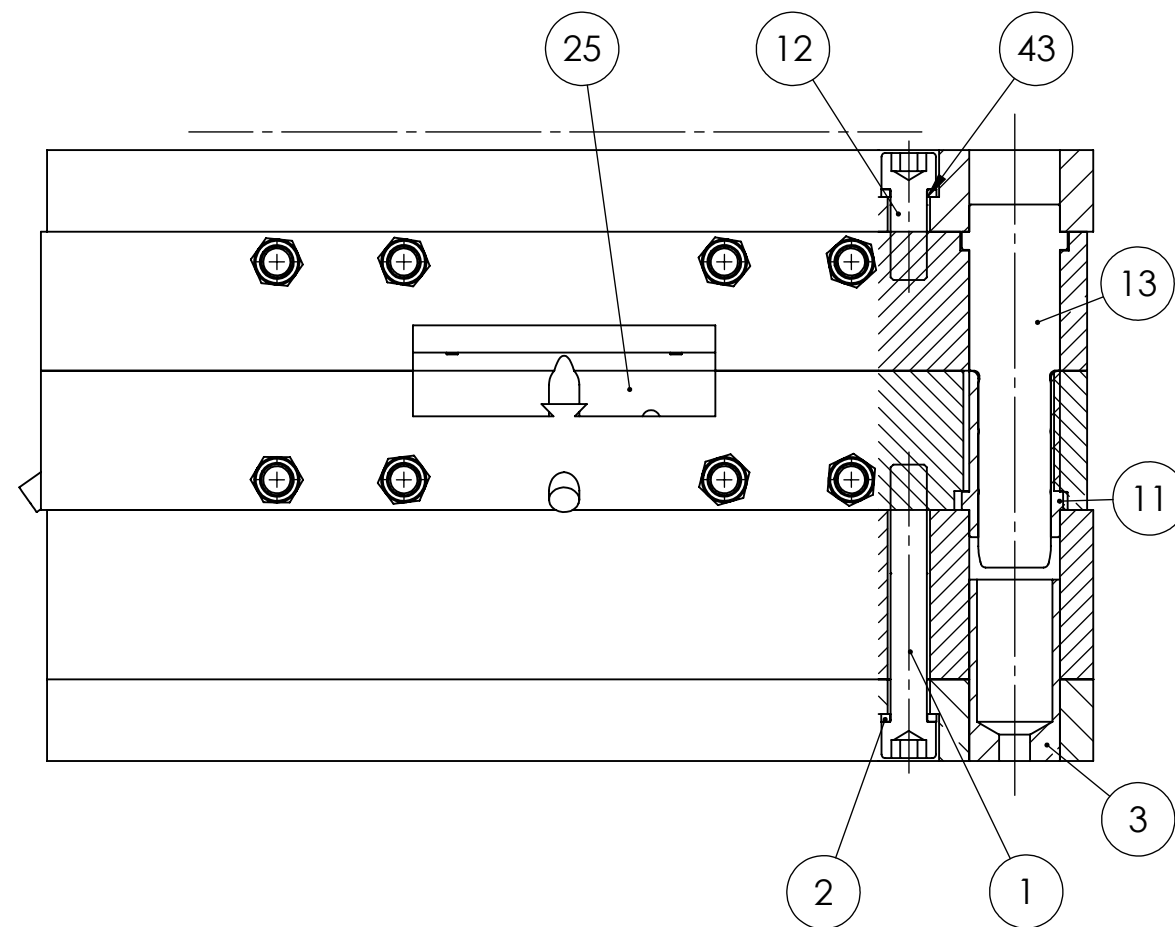
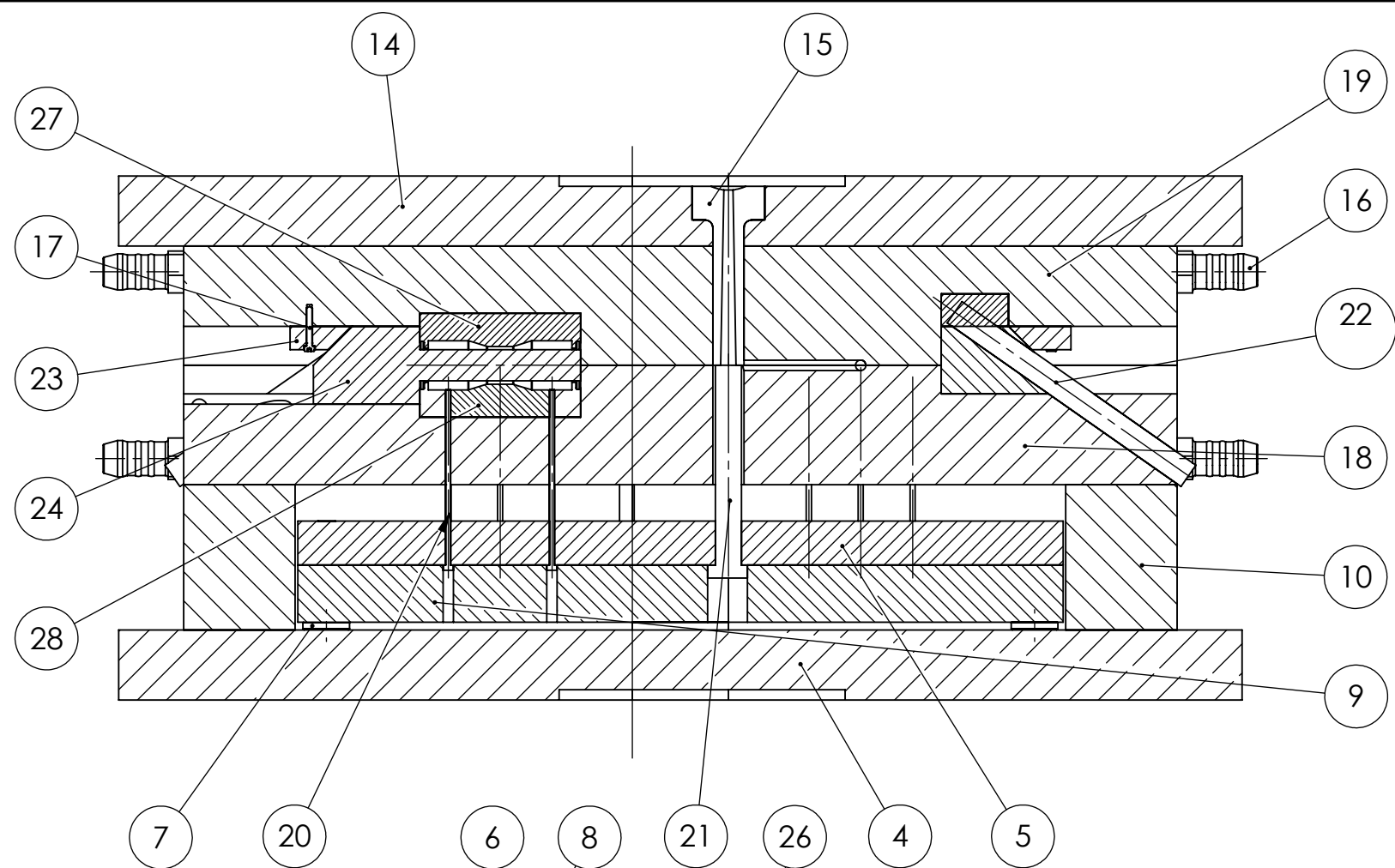
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# DESIGN OF AN INJECTION MOULD PLANES


AUTOR: DANIEL PÉREZ GARCIA

DIRECTOR: MIGUEL SÁNCHEZ-SOTO

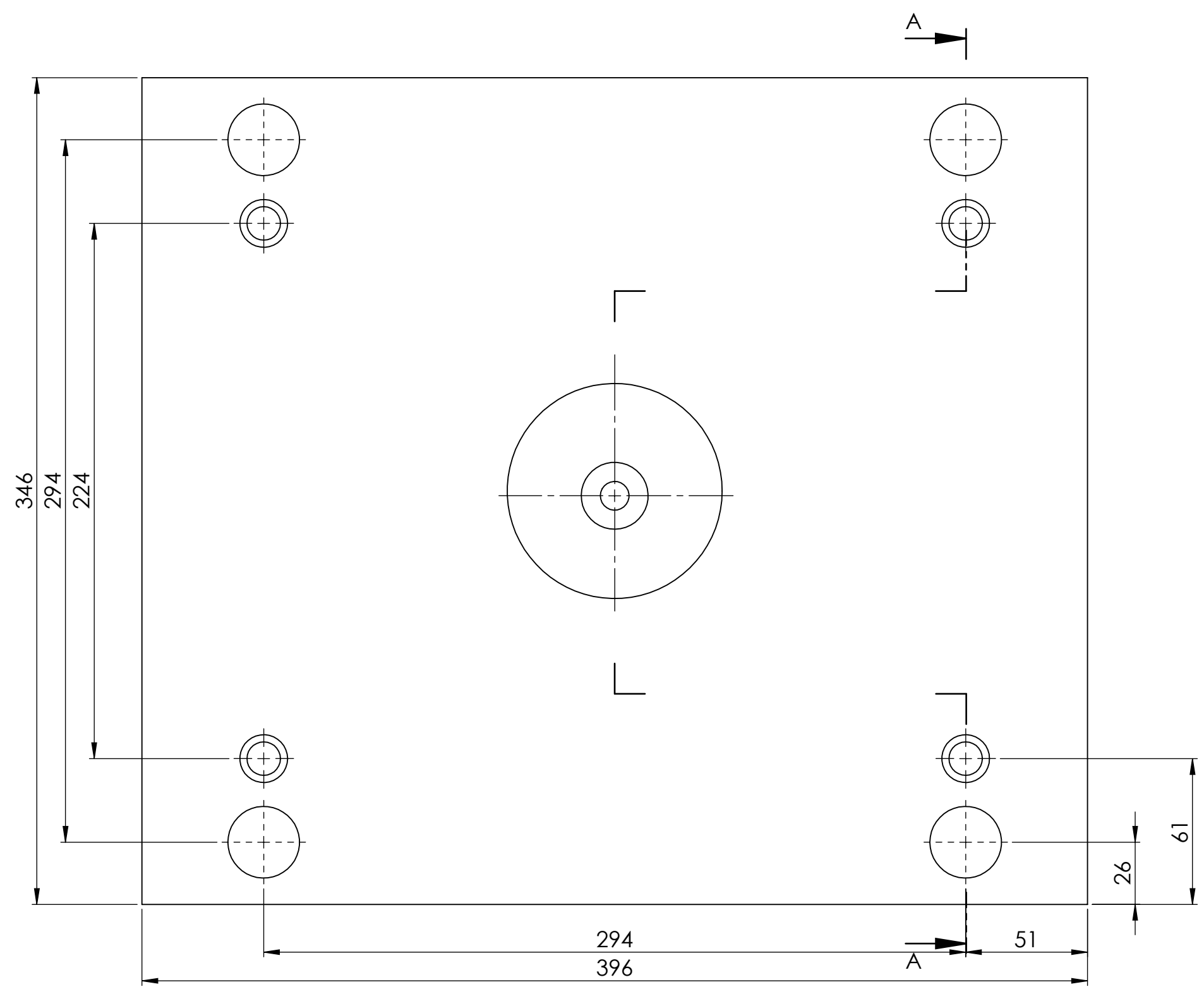
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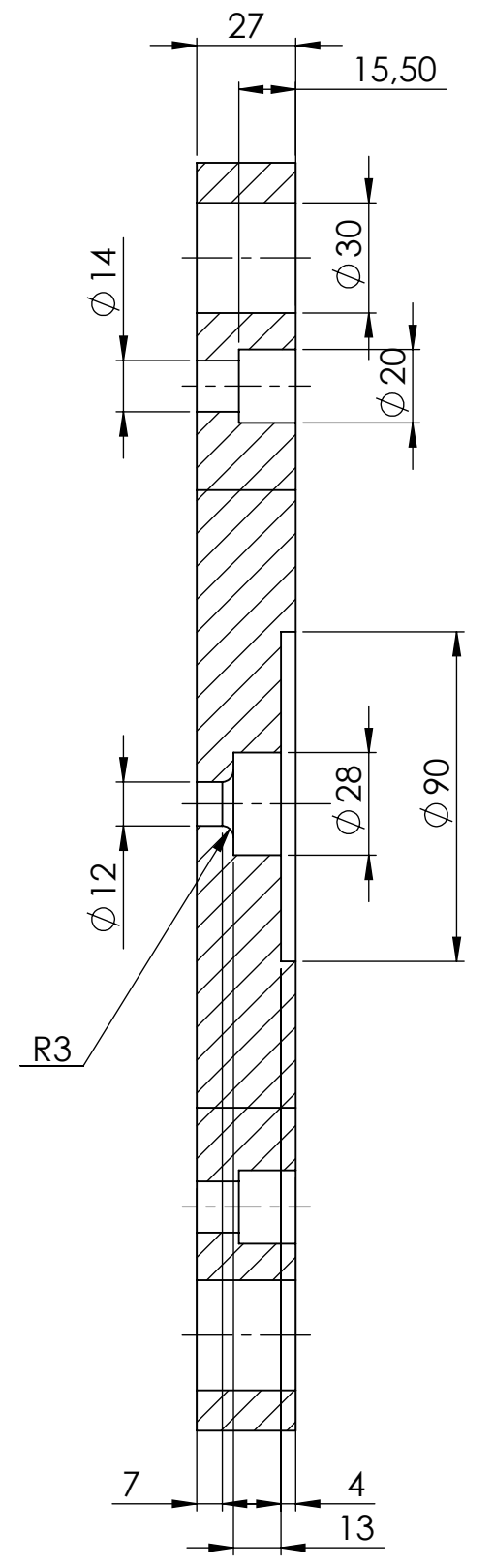
Mark	Name	Code	Quantity	Material
1		Z31_12x85	4	DIN 912
2		Z691_12x2,5	8	-
3		Z20_30x60	4	DIN 690
4	Plate 1	K10_346x346x27	1	DIN 1.2085
5	Plate 4	K60_346x346x17	1	DIN 1.2085
6		Z33_4x8	4	DIN 7991
7		Z55_18x3	4	DIN 1.0711
8		Z31_8x30	4	DIN 912
9	Plate 5	K70_346x346x22_1.2085	1	DIN 1.2085
10		K40_346x346x56_1.2085	1	DIN 1.2085
11		Z10_46x24	4	DIN 690
12		Z31_12x30	4	DIN 912
13		Z00_46x24x65	4	DIN 690
14		K10_346x346x27_1.2085_2	1	DIN 1.2085
15		Z511_12x56x3,5x15,5	1	DIN 16752
16		Z87_13x12x1,5	16	DIN 2.0401
17		Z31_2x16	24	DIN 912
18	Plate 3	K20_246x246x46_1.2085	1	DIN 1.2085
19	Plate 2	K20_246x246x46_1.2085_2	1	DIN 1.2085
20		Z40_2x100	12	DIN 1530
21		Z40_10x100	1	DIN 1530
22	Sliding guide		4	DIN 1.1730
23	Shingle		4	DIN 1.1730
24	Side Ejector		2	DIN 1.1730
25	Frontal Ejector		2	DIN 1.1730
26		Z37_10x19	8	DIN 1.0718
27	Top part housing		4	DIN 1.1730
28	Bottom part housing		4	DIN 1.1730

 Escola d'Enginyeria de Terrassa - E E T	Project denomination: <b>Sliding Injection Mould design</b>		A3		Name, surname: <b>Pérez García, Daniel</b>	
	Plane denomination: <b>Mould Assembly</b>				Est.sup.UNE 1037/Tol.gral.ISO 2778-K/Tol.geom.ISO 2778-m	
	Plane abbreviation: <b>P0</b>		1 : 2,5		20/05/1	



1.  $\nabla$  N8



SECTION A-A



- Mechanization:
- Hole for the nozzle

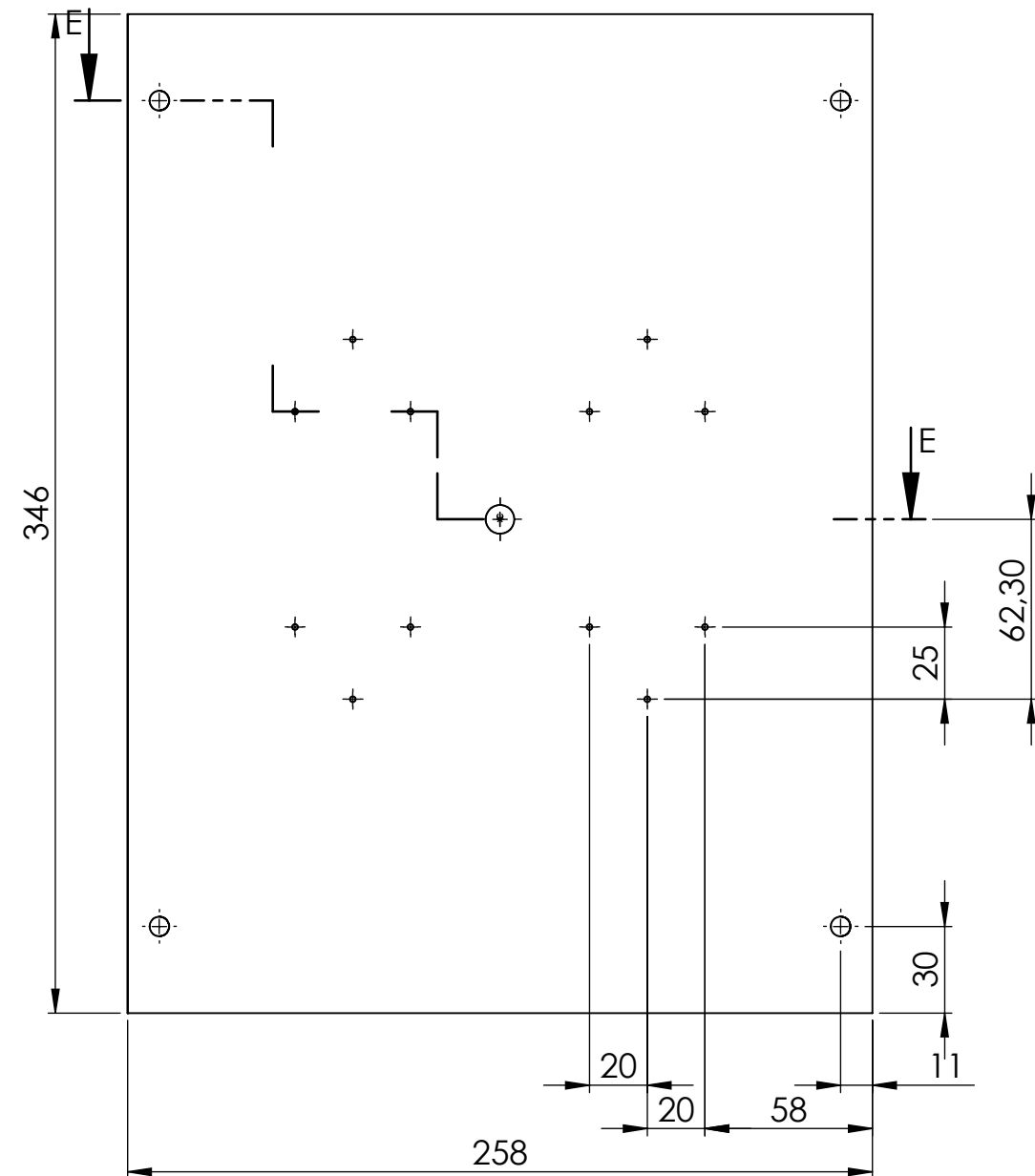
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	Plane denomination <b>Plate 1</b>			Est.sup.UNE 1037/Tol.gral.ISO 2778-K/Tol.geom.ISO 2778-m		
	Plane abbreviation P1			Layover 1 : 2,5	Date 20/05/1	



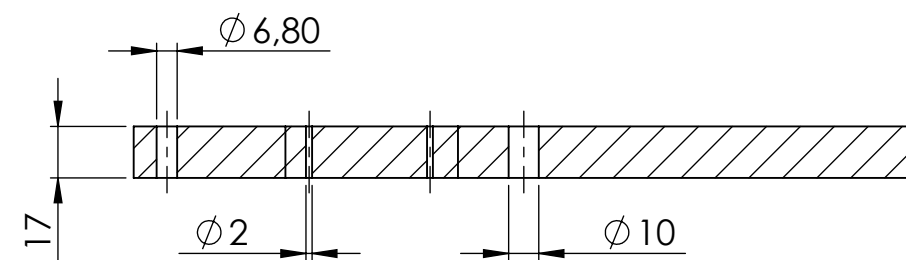


4.  $\nabla$  N8

Plate 4



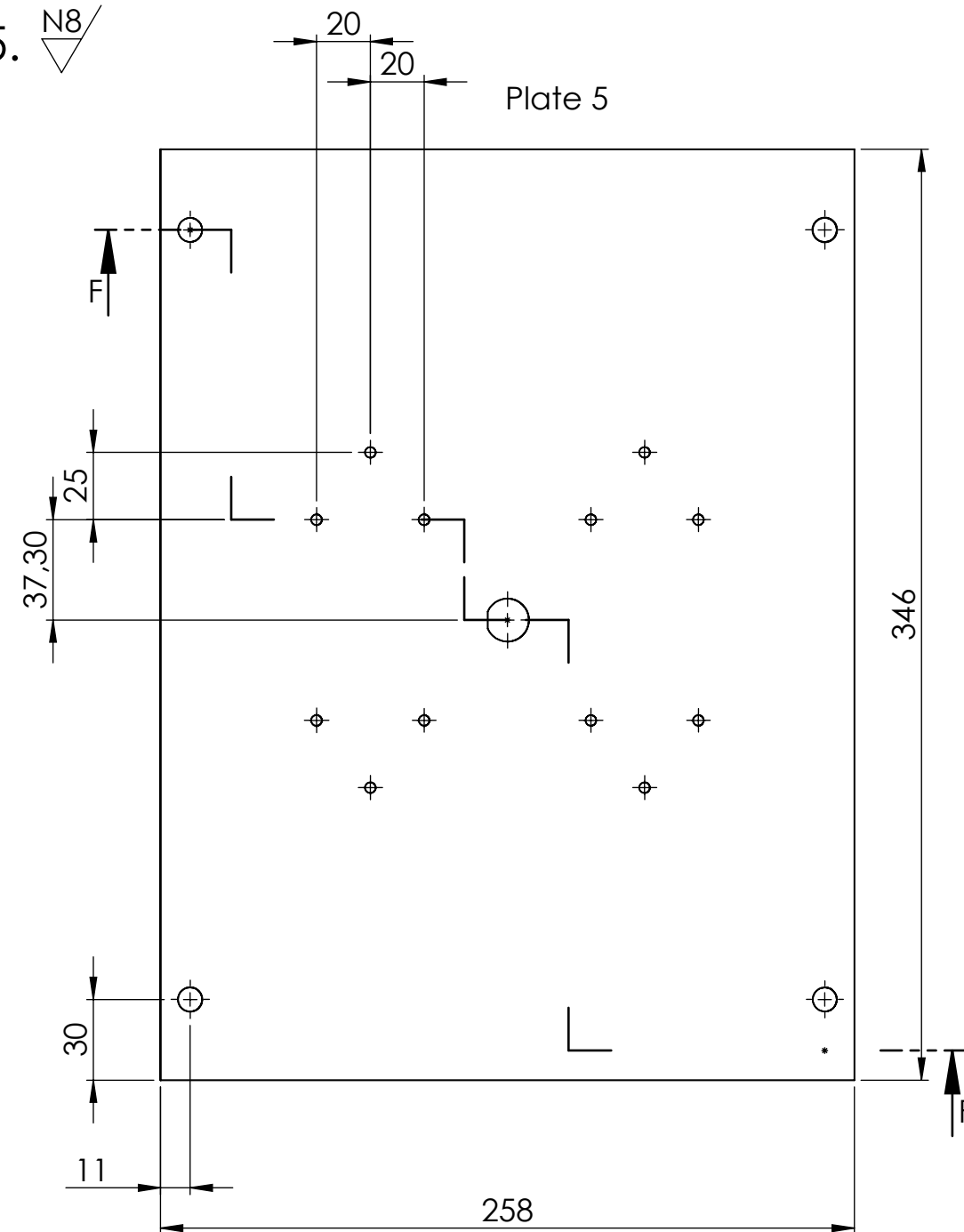
- Mechanization:
- Holes for ejector pins
  - Hole for runner ejector pin



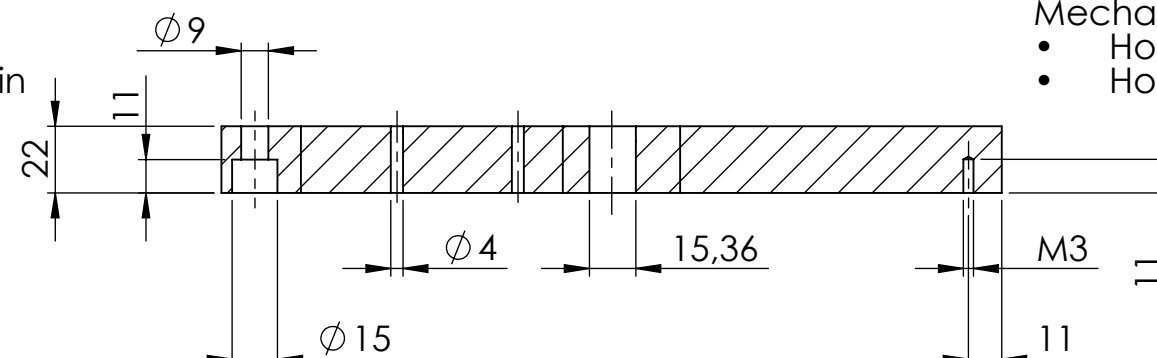
SECTION E-E

5.  $\nabla$  N8



Plate 5



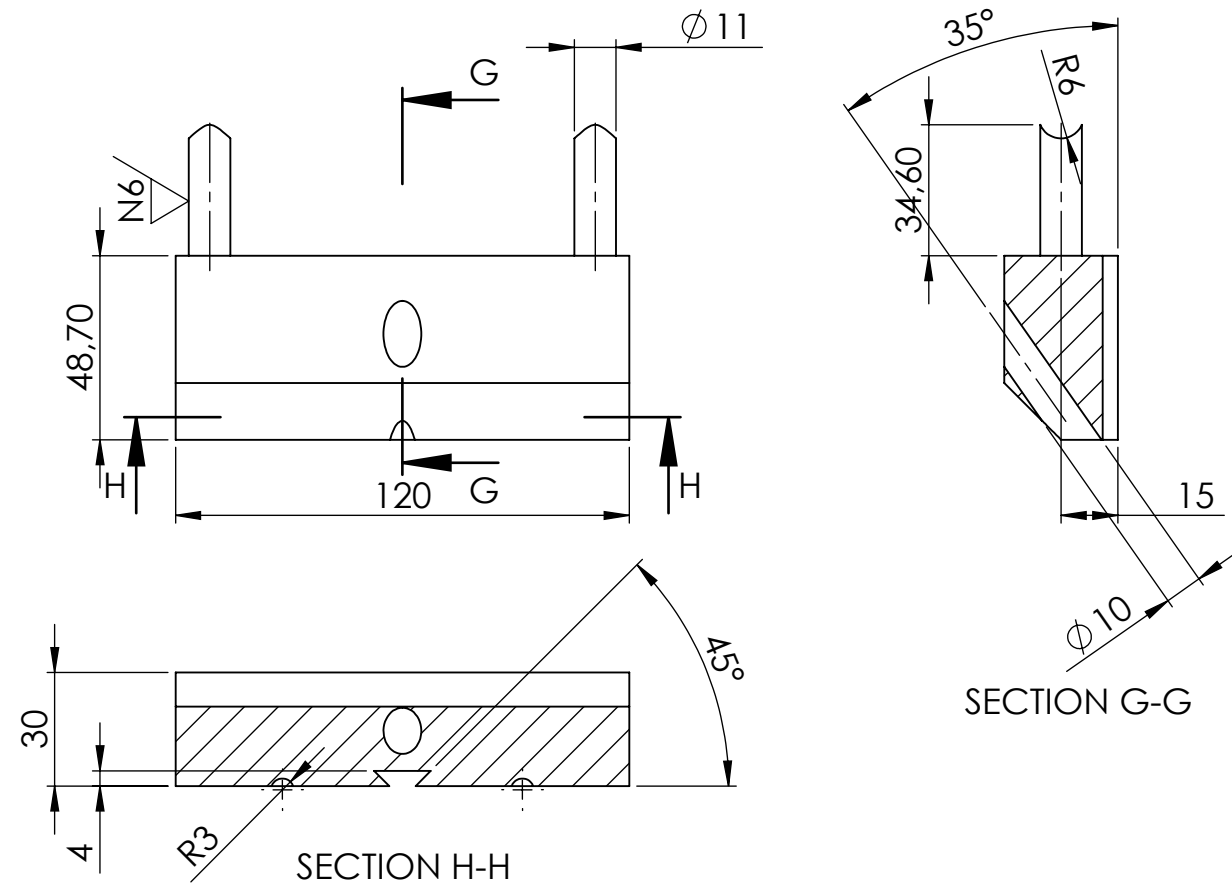
- Mechanization:
- Holes for ejector pins
  - Hole for runner ejector pin



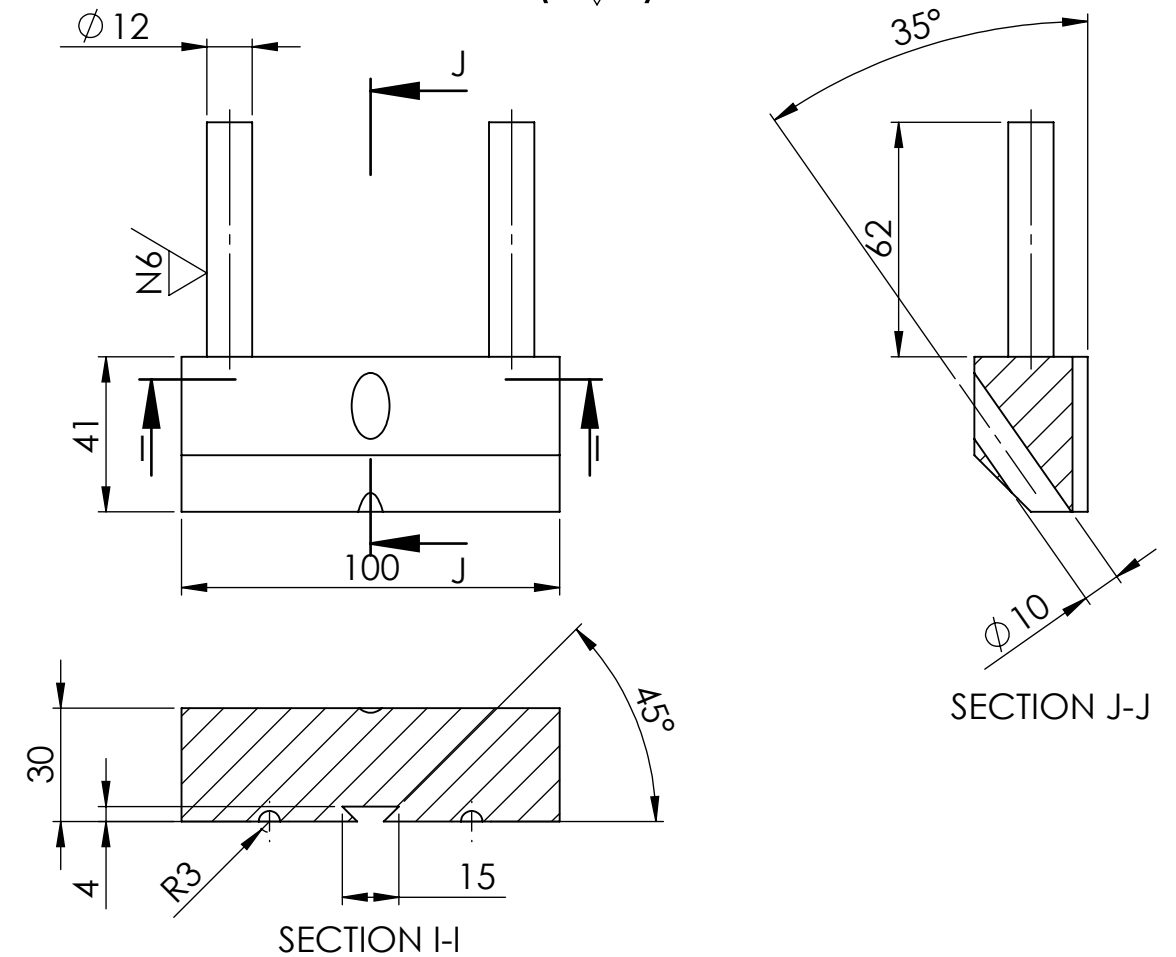
SECTION F-F

 <div>Escola d'Enginyeria de Terrassa - E E T</div>	<div>Project denomination: Sliding Injection Mould design</div> <div>A3</div>	<div>Name, surname: Pérez García, Daniel</div>		
 <div>UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH</div>	<div>Plane denomination Plates 4 &amp; 5</div>		<div>Est.sup.UNE 1037/Tol.gral.ISO 2778-K/Tol.geom.ISO 2778-m</div>	
	<div>Plane abbreviation P4</div>	<div>Layover 1 : 2,5</div>	<div>Date 20/05/1</div>	

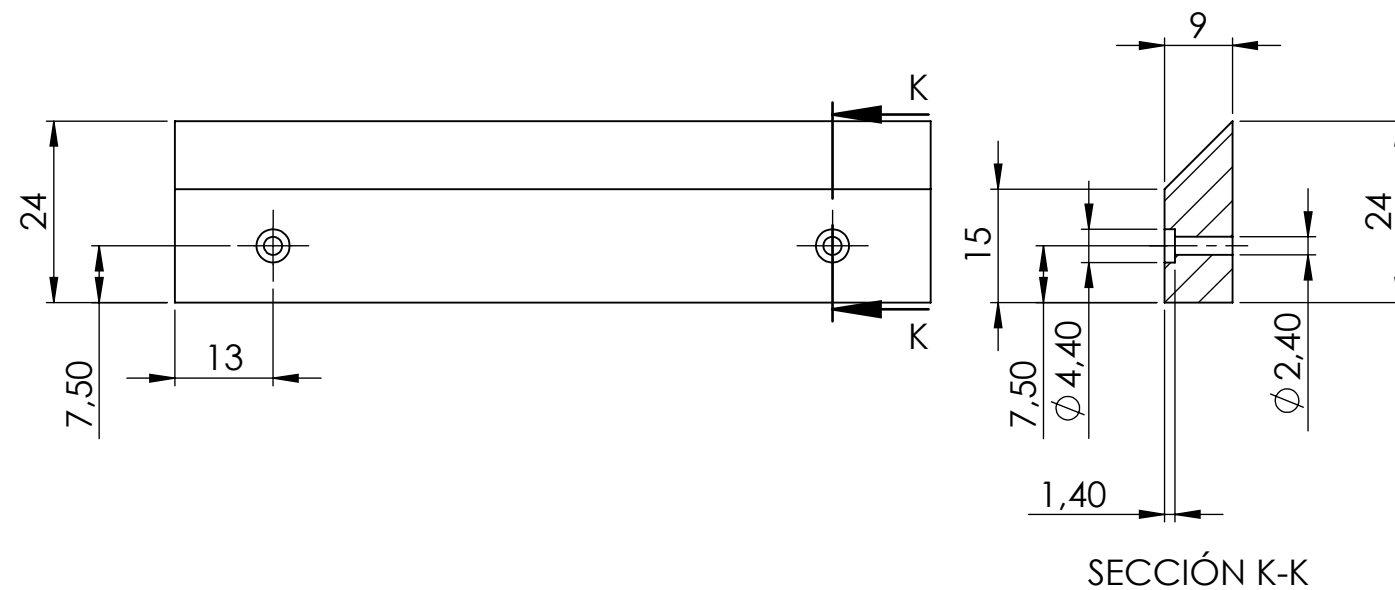
6.  $\nabla \frac{N8}{N6}$  Frontal Ejector





7.  $\nabla \frac{N8}{N6}$  Side Ejector



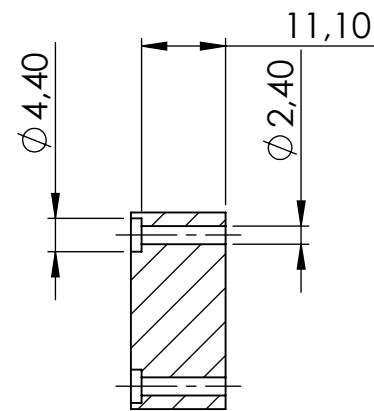
8.  $\nabla \frac{N8}{N6}$  Shingle



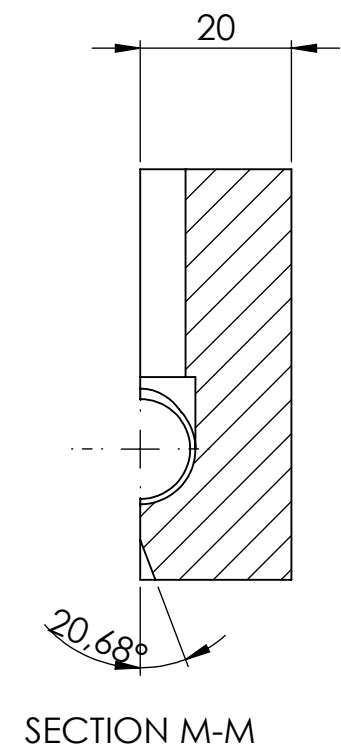
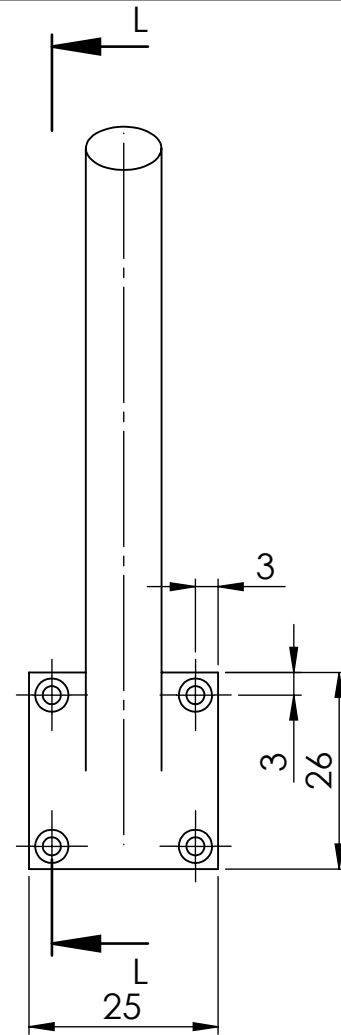
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 <div>UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH</div>	<div>Plane denomination Frontal and Side Ejectors and shingle</div>		<div>Est.sup.UNE 1037/Tol.gral.ISO 2778-K/Tol.geom.ISO 2778-m</div>		
	<div>Plane abbreviationP5</div>		<div>Layover 1 : 1</div>	<div>Date 20/05/1</div>	



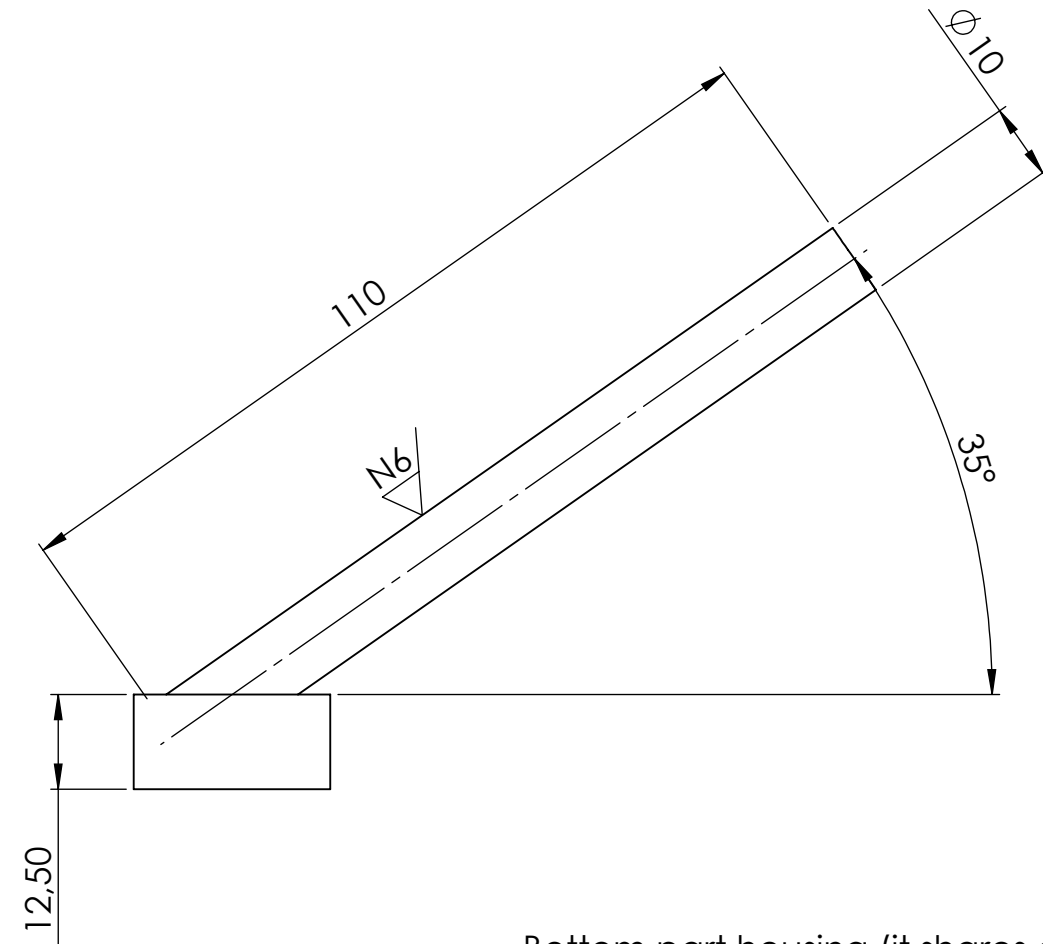
9.  $\nabla \frac{N8}{( \nabla \frac{N6}{})}$



SECTION L-L

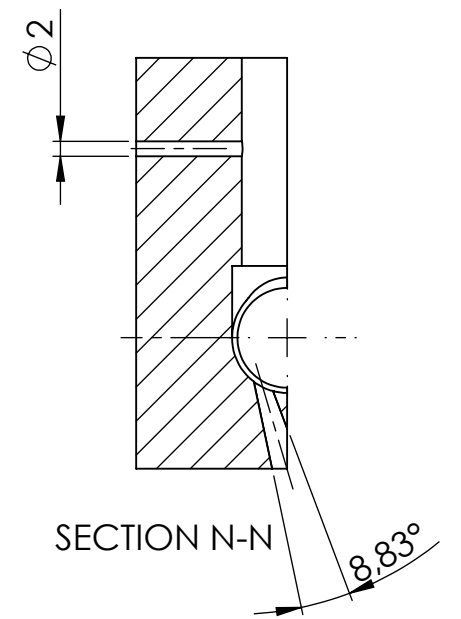
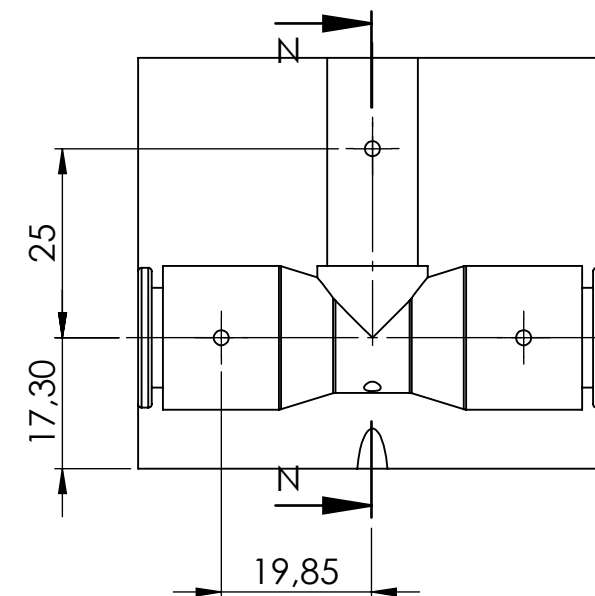


SECTION M-M



10.  $\nabla \frac{N6}{}$

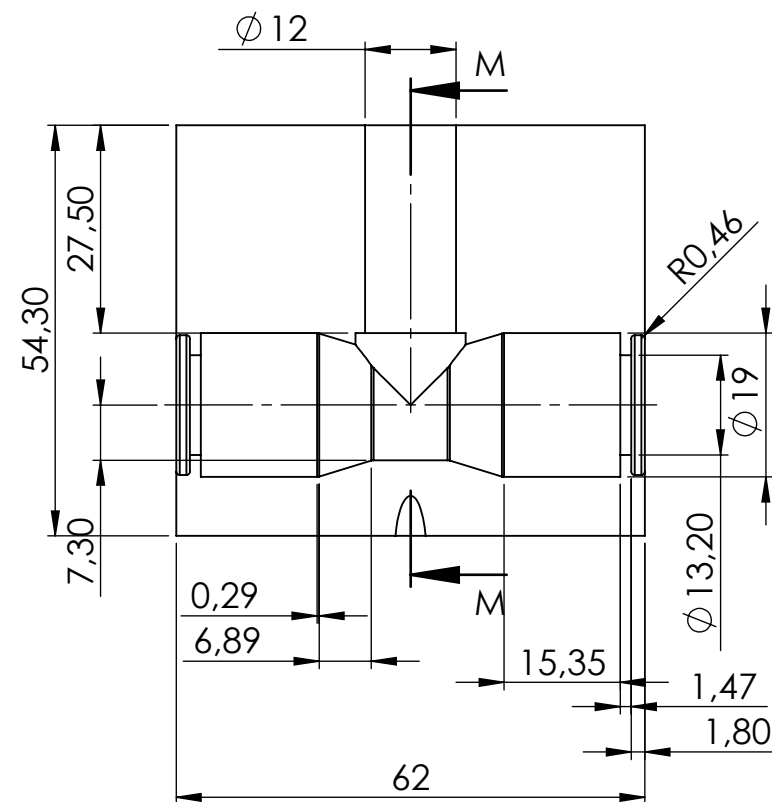
Bottom part housing (it shares dimensions with top part housing but the bottom part has 3 holes for ejector pins and a hole for injecting the plastic on it)





SECTION N-N

10.  $\nabla \frac{N6}{}$

Top part housing



SECTION M-M

 <b>UNIVERSITAT POLITÈCNICA DE CATALUNYA BARCELONATECH</b>	 Escola d'Enginyeria de Terrassa - E E T	Project denomination: <b>Sliding Injection Mould design</b>		Name, surname: <b>Pérez García, Daniel</b>		
		Plane denomination: <b>Sliding guide and top and bottom part housing</b>		Est.sup.UNE 1037/Tol.gral.ISO 2778-K/Tol.geom.ISO 2778-m		
		Plane abbreviation: <b>P6</b>		Layover: <b>1 : 1</b>	Date: <b>20/05/1</b>	